Australian Government
Department of Defence
Defence Science and
Technology Organisation

Assessment of Nutritional Status and Fatigue among Army Recruits during the Army Common Recruit Training Course
Part B: Psychological and Health Aspects

Bianka Skiller, Christine Booth, Ross Coad and Chris Forbes-Ewan

Human Protection & Performance Division
Defence Science and Technology Organisation

DSTO-RR-0300

ABSTRACT

Researchers conducted a nutritional survey of all food available to recruits at ARTC, and recruits from two platoons self-recorded their quality of sleep, symptoms of fatigue and ill health, mood state, level of coping ability and dietary intake. Injury data were recorded by the Defence Injury Prevention Program. Fasting blood measures of immune status, hormones (serum free testosterone to cortisol ratio), inflammation and iron status were measured on three occasions. Mean total energy expenditure was estimated by the 'factorial method'. Components of physical fitness (aerobic endurance, strength and muscular endurance, and explosive power) were measured on three occasions. Height was measured initially and well-hydrated weight measured on three occasions. The study was conducted in two phases; the recommendations of the first phase, which specifically addressed dietary issues were presented in Part A of this report. The second phase, which investigated the proposition that recruits might display symptoms of overtraining, is addressed in this report. We conclude that there was some evidence for recruits being overtrained. The combined demands of the 45-day Army Common Recruit Training course, resulted in a significant prevalence of overtraining symptoms such as fatigue, sleep disturbance, immune suppression, reduced iron status, high rate of minor injuries and hormonal changes. However, recruits were not pushed so hard that physical performance deteriorated greatly. Accumulated sleep deprivation might be a major contributor to the adverse hormonal changes.

Published by

Human Protection & Performance Division
DSTO Defence Science and Technology Organisation
506 Lorimer St
Fishermans Bend, Victoria 3207 Australia

Telephone: (03) 9626 7000
Fax: (03) 9626 7999

AR-013-489
July 2005

Assessment of Nutritional Status and Fatigue among Army Recruits during the Army Common Recruit Training Course
Part B: Psychological and Health Aspects

Executive Summary

The Commanding Officer/Chief Instructor of the Recruit Training Wing (CO/CI RTW) was concerned by his observations that most recruits required long recovery times after physically demanding activities and lacked energy during classroom activities.

In order to address these concerns DSTO researchers conducted a nutritional survey of all food available to recruits at the Army Recruit Training Centre. Recruits from two platoons self-recorded their quality of sleep and ill-health (daily), symptoms of fatigue and mood state (weekly), level of coping ability (two occasions) and dietary intake (two occasions) while completing the 45-day Army Common Recruit Training (ACRT) course. Fasting blood samples were collected on three occasions. Changes in immune status were monitored by measuring *in vivo* serum inflammatory cytokines and a differential count of white cell populations. Biochemical markers of the onset of overtraining—serum free testosterone to cortisol ratio, serum ferritin and C-reactive protein—were measured. Mean total energy expenditure (TEE) was estimated for the group by the 'factorial method'. Components of physical fitness (including aerobic endurance, strength and muscular endurance, and explosive power) were measured during usual physical training sessions (three occasions). Recruits' body weight was monitored (three occasions). Timetabling restraints did not permit other key physiological indicators such as resting heart rates, blood pressure and body composition to be recorded. Injury data for the group were collected by the Defence Injury Prevention Program.

The study was conducted in two phases; the recommendations of the first phase, which specifically addressed dietary issues were presented in part A of this report (published separately). The second phase, which investigated the proposition that recruits might display symptoms of overtraining, is addressed in this report.

We conclude that there was some evidence for recruits being overtrained. The combined demands of the ACRT, which included physical and psychological stresses, combined with inadequate nutrition resulted in a significant prevalence of overtraining symptoms such as fatigue, sleep disturbance, immune suppression, reduced iron status, high rate of minor injuries and hormonal changes. However, recruits were not pushed so hard that physical performance deteriorated greatly. Accumulated sleep deprivation might be a major contributor to the adverse hormonal changes.

Poor iron status is of concern. There was evidence of iron-deficiency and iron-deficiency anaemia among both male and female recruits. More disturbing was the possibility that three recruits from the two platoons tested might have had the iron-overload condition, haemochromatosis.

These data suggest that the level of the training tempo be adjusted to minimise the symptoms of overtraining. In particular it might be possible to adjust the training program to avoid the high levels of confusion and mental fatigue and the decline in friendliness. This might be achieved by providing recruits with periods of personal time for recreation, relaxation or rest. Team cohesiveness might benefit from decreasing competitive behaviour and improving interpersonal interactions. Better sleep management might assist in prevention of negative hormonal changes. Improved diet (as described in Part A of this report) should assist in minimising fatigue and improving sleep quality. It is important to ensure that recruits have sufficient and good quality rest before commencing their next military training course. Measures should be put in place to monitor recruits' iron status.

The following summarises the recommendations made in this report:

1. The dietary changes recommended in part A of this report should be implemented and a watching brief for new and innovative nutritional strategies to boost performance should be maintained by DSTO or ADF nutritionists.
2. The pre-physical fitness standard needs to be critically assessed in order to decrease the prevalence of overtraining symptoms experienced by recruits. Furthermore recruits should be well rested before commencing the ACRT.
3. Personal time for recreation, relaxation or rest should be included in the ACRT timetable. Allowing recruits time out from the high stress of the course, through planned personal time, might improve the profile of high levels of confusion and mental fatigue and low levels of friendliness seen among these recruits. The Profile of Mood States and Multi Symptom Fatigue Inventory-Short Form questionnaires can be used to monitor any changes to the training program.
4. Strategies for better sleep management need to be considered. Accumulated sleep deprivation along with an inadequate supply of carbohydrate throughout the day is likely to decrease the recruits' ability to concentrate on tasks, particularly in the early morning and during the evening. The simple sleep diary used in the present study can be used to monitor changes in recruits' sleeping patterns.
5. Cognitive hardiness, or the ability to cope, was found to be a potential predictor of recruits failing to complete the ACRT. The possibility that cognitive hardiness can either be improved, or used during the recruitment process, could be the subject of further investigation. DSTO or ADF psychologists could assist in the conduct of this research.
6. Iron status should be monitored. Universal screening of recruits for iron status would be very expensive and not warranted. However, screening of recruits at high risk, for example females and regular blood donors, should be considered. Problems of iron-deficiency and iron overload should be referred for medical attention.
7. Recruits should be given sufficient and good quality rest before embarking on further physically and/or psychologically demanding training.

Authors

Bianka Skiller
Human Protection & Performance Division

Bianka graduated from LaTrobe University with a BAppSc (Hons) in 1999 and is currently studying a Masters of Health Science-Human Nutrition (Deakin University). Bianka has been employed at DSTO-Scottsdale since 1999 and working in the fields of food technology, microbiology, biochemistry and nutrition.

Christine Booth
Human Protection & Performance Division

Christine graduated from the University of Queensland (UQ) with BSc(Hons) and PhD (1992) in biochemistry (enzymology - cofactors and vitamins). She has also obtained qualifications in education (Dip Ed, UQ) and dietetics (Grad Dip Nutr Diet, QUT) and is an accredited practicing dietitian. She has membership of the Australasian Association of Clinical Biochemists, American Association of Clinical Chemists, Dietitians' Association of Australia, Nutrition Society of Australia and is an Honorary Research Associate in the School of Human Life Sciences, University of Tasmania. Christine has held research positions within UQ and QUT and a supervising scientist position within Chemical Pathology at Royal Brisbane Hospital. As a senior researcher at the DSTO-Scottsdale Christine has been investigating the nutritional status of soldiers and the effects of long-term combat rationing on health and military performance.

Ross Coad
Human Protection & Performance Division

Ross has been employed at the DSTO-Scottsdale since 1988, working in the fields of chemistry, food technology, microbiology and nutrition. He has a Masters of Business Administration - Technology Management (Latrobe University), BAppSc (University of Tasmania) in Chemistry and Geography, and an Assoc Dip in Laboratory Technology (Riverina-Murray Institute of Higher Education). He is a Member of the Royal Australian Chemical Institute, Member of the Australian Institute of Food Science and Technology and a Member of the Nutrition Society of Australia. Ross is the current Task Manager of research concentrating on fatigue, nutrition and fitness on navy vessels.

Christopher Forbes-Ewan
Human Protection & Performance Division

Chris graduated from the Australian National University with an honours degree in biochemistry in 1972. Chris has more than 30 years experience in food science, nutrition and exercise physiology. In 1986 Chris was appointed to the position of Senior Nutritionist. In that time he has led a team that has conducted extensive research into food acceptability, food intake, energy expenditure and physical performance enhancement of ADF members. For 10 years Chris was the Australian National Leader of an international defence technical panel under The Technical Cooperation Program (TTCP). This technical panel conducted collaborative and cooperative research into performance enhancement for special and conventional military operations. Currently Chris is continuing his research into aids to military performance and nutritional promotion of health and military fitness. Chris is an Associate of the Australian Institute of Food Science and Technology, member of the Nutrition Society of Australia, of the Australian Society of the Study of Obesity and of the International Society of the Advancement of Kinanthropometry.

Contents

1. Introduction

The role of the Army Recruit Training Centre (ARTC) is to develop and deliver all-corps soldier training and adventurous training to the ADF, the primary focus being recruit training for the Regular and Reserve Army. During 2003 3900 recruits completed the 45-day recruit training course, called the Army Common Recruit Training course(ACRT). Training is conducted continuously over the 45 days with most days commencing at 0600 h and finishing at 2200 h. The course is both physically and psychologically demanding, with very little personal time.

Both the ACRT and international recruit training programs report a high incidence of recruits failing to complete [1]. Reasons for failure include injury or illness, self-requested discharge and poor psychological suitability [1, 2, 3]. In 1999, a cohort study of 1,317 male recruits undertaking 12 weeks of basic training at ARTC recorded 184 recruits being discharged from the Army. Of these recruits most were discharged as "medically unfit" (59%), 23% were discharged at their own request and 18% were discharged as "not suited to be a soldier" [3]. A lower limb injury was sustained in 21% (276) of the recruits with tibial stress fracture or periostitis accounting for 36% of these injuries. Injured recruits were 10 times less likely to complete recruit training. Such attrition costs thousands of dollars per recruit – ie the combined costs of recruitment, relocation to ARTC, uniforms, equipment, accommodation, rations, wages, instruction and supervision, administration and health care.

In response to the observation by the Commanding Officer/Chief Instructor of the Recruit Training Wing (CO/CI RTW) that most recruits require long recovery times after physically demanding activities and lack energy during classroom activities, the Defence Science and Technology Organisation (DSTO) recommended appropriate nutritional strategies to lessen the observed level of fatigue among the recruits [4]. A summary of the recommendations is included at Appendix A.

1.1 Could Army recruits be "overtrained"?

The proposition that the combined demands of the ACRT, which include physical and psychological stresses, combine with inadequate nutrition to result in a significant prevalence of overtraining symptoms such as fatigue, under performance, immune suppression and hormonal changes was investigated with recruits undertaking the ACRT during October-November 2003. One of the dangers with overtraining is an increased risk of injury [5].

A situation of overtraining (or overreaching) can occur in response to demanding training loads in all population groups – not just elite athletes. For example, symptoms of overtraining have been documented during military training in other countries [6, 7] including the USA [8], Spain [9] and Norway [10]. Overtraining symptoms include fatigue, changed mood, under performance, immune suppression, frequent colds and sore throats, weight loss and hormonal changes and are more likely to develop when

physical training is combined with other stresses such as psychological stress and inadequate nutrition [9,11]. In fact similar symptoms are also found with chronic fatigue syndrome and clinical depression, namely persistent fatigue, mood-state disturbances and muscle soreness [12,13]. Physiological markers of overtraining include increased resting heart rate, increased resting blood pressure, increased maximal plasma lactate concentration during exercise, decreased serum ferritin, decreased aerobic capacity and decreased anaerobic power [7,11].

An individual's susceptibility to overtraining will depend on factors such as their exercise capacity, recovery potential and ability to cope with stress. It is believed that large volumes of physical training and psychological stresses without adequate rest and recovery leads to the development of overtraining symptoms and the larger and more abrupt the increase in the training intensity/duration the more likely it is for individuals to develop symptoms [7,11].

Another factor in the development of overtraining symptoms is diet. Diets which provide inadequate carbohydrate (both quantity and time of delivery) and inadequate antioxidants and which are high in saturated fats and/or n-6 polyunsaturated fats can increase the risk of recruits developing overtraining symptoms [13, 14, 15, 16, 17].

1.2 The present study

Researchers conducted a nutritional survey of meals and other food available to recruits from all sources at ARTC, and recruits from two platoons self-recorded their quality of sleep, symptoms of fatigue and ill health, mood state, level of coping ability and dietary intake. Changes in immune status were monitored by measuring *in vivo* serum inflammatory cytokines and a differential count of white cell populations. Biochemical markers of the onset of overtraining—serum free testosterone to cortisol ratio [7, 9], serum ferritin and C-reactive protein—were measured [11]. Mean total energy expenditure (TEE) was estimated for the group by the 'factorial method'. Components of physical fitness (including aerobic endurance, strength and muscular endurance, and explosive power) were measured during usual physical training sessions. Height was measured initially and well-hydrated weight measured on three occasions throughout the ACRT. Timetabling restraints did not permit other key physiological indicators such as resting heart rates, blood pressure and body composition to be recorded.

The study was conducted in two phases; the recommendations of the first phase, which specifically addressed dietary issues are presented below (Appendix A). The second phase, which investigated the proposition that recruits might display symptoms of overtraining, is addressed in this report.

1.3 Methods

1.4 Participants and study protocol

1.4.1 Ethics approval

The experimental procedures were approved by the Australian Defence Human Research Ethics Committee (ADHREC protocol 333/03). All potential participants received copies of the information form and ADHREC's "Guidelines for Volunteers". Written consent was obtained from each participant after the details of the study had been explained and volunteers' questions had been answered. Copies of the forms are included in Appendix B.

1.4.2 Study protocol

The 45-day ACRT involves activities ranging from 40-minute lessons—which can be sit-down classes, physical training or drill—to longer field-training sessions. All activities, including personal recreational time, need to be scheduled so that the demanding requirements of the course can be met within the 45-day timeframe. The tests that were required for the present study were no exception. The testing elements were scheduled into the formal timetable for the participating platoons. Briefly, the testing schedule was as follows:

- dietary questionnaires/diary were completed on day 1 and during week 5;
- fitness testing was conducted at the beginning (day 3, week 1), mid-course (day 18, week 3) and end-of-course (day 32, week 5);
- blood samples were collected on day 1, before (week 5, day 33) and after the final physical assessments (week 7, day 43);
- sleep and health diaries were completed each day, and
- the psychology questionnaires were completed on the same day each week.

1.4.3 Participants

Recruits from two platoons were invited to take part in this study during 2003. Of 51 males (28 Regular Army and 23 Reservists) and seven females (two Regular Army, five Reservists) who volunteered for the study, five females and 38 males completed the ACRT and the study. We are not aware of the reasons for recruits dropping out of the study and cannot speculate how the lost data might have affected the study outcomes.

The mean age of the initial group was 22.0 years for the males (range 18–33 years) and 29.5 years for the females (range 19 – 46 years). Mean height for males was 179.5 cm (range 164 – 196 cm) and females 165.0 cm (range 160 – 171 cm). Mean weight for males was 78.8 kg (range 60 – 104 kg) and females 64.5 kg (range 57 – 74 kg). Of the 39 males who completed the study, 14 (36%) were classified as *overweight* (body mass index (BMI) $\geq$ 25.0) at entry to the ACRT (mean BMI = 24.3, range 20.1 - 29.4) and two of the five females (40%) were *overweight* (mean BMI = 24.3, range 21.1 – 28.6). No recruits were classified as obese (BMI $\geq$ 30.0). Nine males and no females were cigarette smokers at commencement of the ACRT.

1.5 Physiological measurements

1.5.1 Anthropometry

The methods for recording anthropometric data were based on those of the International Society for the Advancement of Kinanthropometry. Body weight (Scales Model: 211FP, Mercury Scale Co. Pty Ltd) and stature (stadiometer Cat no. 4444, Ka We Mab) were recorded before breakfast during the blood collection sessions (i.e. days 1, 33 and 43). Participants were requested to drink plenty of water the night before testing so as to be in a well-hydrated state the following morning.

1.5.2 Physical performance

Tests of physical performance were conducted during regular physical training sessions under the supervision of the physical training instructors at ARTC. The 2.4 km run was used as a measure of aerobic capacity and endurance, maximum number of push-ups as a measure of strength and standing vertical jump as a measure of explosive power.

1.5.3 Injury data

The Defence Injury Prevention Program conducts injury surveillance at the ARTC Kapooka and kindly provided the injury data for this study. The data is included in Appendix G. Individual recruits were not identified in the provision of this data.

1.6 Psychological and health measurements

Historically fatigue has been viewed as unidimensional with the result that researchers have focused on the severity or intensity of symptoms *per se*. However, it is now recognised that fatigue is a multidimensional phenomenon, which encompasses physical, affective, social and cognitive symptom domains [18]. The Profile of Mood States (POMS) Fatigue subscale is recognised as a reliable measure of fatigue, but it is unidimensional; ie it doesn't discriminate between symptom domains. The multidimensional fatigue measure, the Multidimensional Fatigue Symptom Inventory - short form (MFSI-SF) was included in this study to provide a profile of the physical, emotional, mental, vigour and general fatigue domains.

1.6.1 Fatigue questionnaire

Fatigue was monitored once each week by use of the MFSI-SF. It is a validated questionnaire sensitive enough to detect changes in fatigue over short periods [18]. It comprises 30 items, participants rated their experience of each symptom—how true for you in the past 7 days—according to a 5-point Likert scale (ie *not at all*, *a little*, *moderately*, *quite a bit* or *extremely*, see Appendix C). The item scores combine to produce five subscales measuring different dimensions of fatigue: general fatigue, physical fatigue, emotional fatigue, mental fatigue and vigour.

Because the MSFI-SF has a 7-day time frame, it can be administered at frequent intervals. It contains no reference to medical conditions so it can be used by both healthy and ill individuals. It does not assume the presence of fatigue—so it can be used to gather baseline data, before an expected fatigue-inducing event/activity. The subscales can be compared. For example individuals may be free of physical fatigue symptoms but have symptoms of other fatigue dimensions such as emotional fatigue. This can assist in designing appropriate interventions. Specific patterns of fatigue for individuals or groups may be identified.

1.6.2 Mood questionnaire

Changes in mood state were monitored once each week by use of the Profile of Mood States (POMS) questionnaire [19]. Participants rated the 65-item list of words—how you have been feeling during the past week including today — according to a 5-point Likert scale (Appendix D). The POMS was scored for each of the factors, tension-anxiety, depression-dejection, anger-hostility, vigour-activity, fatigue-inertia, confusion-bewilderment, friendliness and total mood disturbance.

1.6.3 Cognitive hardiness scale

The cognitive hardiness scale (CHS) is a 30-item validated psychometric instrument which required participants to respond to belief statements according to a 5-point Likert scale (Appendix E) [20]. The CHS is scored by summing the values of the 30 items. High scores indicate high levels of cognitive hardiness.

1.6.4 Sleep disturbance and general health diary

Participants completed a daily sleep and health diary (Appendix F). This diary, which was modified from a similar diary developed by the Psychology Department, Sleep Research Group of the University of South Australia, documented hours of sleep and wakefulness and sleep quality. Sleep quality was scored on a 7-point scale from (1) *extremely poor* to (7) *extremely good*. General health was recorded by use of a simplified 9-point health checklist (Appendix F).

1.7 Biochemistry measurements

1.7.1 Blood collection

All participants reported to the Kapooka Medical Centre at the same time of day (between 0630 and 0830h) after an overnight fast. Blood from each participant was collected from a superficial antecubital vein into an EDTA tube (10 mL, BD Vacutainer, Becton Dickinson, Franklin Lakes, NJ, USA) and a plain serum tube, which contained clot activator and a gel separator (9.5 mL, Vacutainer SST Gel & Clot Activator, Becton Dickinson, Franklin Lakes, NJ, USA).

1.7.2 Haematology and biochemistry tests

A basic haematological profile (haematocrit, Hct, haemoglobin concentration, Hb, red and white cell counts and counts of neutrophils, monocytes and lymphocytes) was performed on whole EDTA blood within 10 hr of collection by use of routine methods (Beckman Coulter MAXM automated analyser, Miami, Florida, USA). The calculated ratio of neutrophils to lymphocytes was calculated as a useful index of the physiological stress on the immune system [21].

The serum free testosterone : cortisol ratio (FTCR) was used to determine the onset of overtraining. The FTCR represents a balance between anabolic and catabolic activity within the tissues. A decrease in FTCR of 30% or more indicates an increased catabolic state and risk of overtraining [7, 9]. Other markers of overtraining, namely ferritin (Frt), C-reactive protein (CRP) and *in vivo* inflammatory cytokines (tissue necrosis factor alpha, TNFα) were also measured from the serum sample.

Samples collected from the 3 time points were batch analysed, ensuring that each participant's samples were analysed within the same day. Reagents from the same production batch were used throughout the analysis. Standard commercial methods were used in the analysis of all blood analytes: free testosterone (Coat-A-Count Radioimmuno assay, DPC Cirrus Inc, Los Angeles , California, USA), TNFα (Accucyte competitive enzyme immunoassay, Cytimmune, Maryland,USA), Frt and high-sensitivity CRP (ProSpec autoanalyser, Dade Behring, Marburg, Germany), and cortisol (Vitros Eci, Johnson & Johnson Clinical Diagnostics Inc,Rochester NY,USA).

1.8 Statistical analysis

All statistical analyses were performed by Dr Glen McPherson, Hobart Tas (consultant statistician). Statistical analyses were performed with SPSS (Statistical Package for the Social Sciences, version 12.0, 2003, SPSS, Inc., Chicago, IL, USA). Descriptive statistics were used to establish a measure of central tendency and presented as means, standard deviations, standard error and range. Data was initially checked for outliers and non-homogeneity of the population by use of pair wise scatter plots, box plots and Q-Q plots. Normality of population distributions was checked by the Shapiro-Wilk and Lilliefors tests. Where appropriate data was log transformed to achieve Normality. Significance was accepted at $p < 0.05$. Associations between variables was assessed by multiple linear regression analyses. Comparison of means was achieved by use of the paired t test with Levene's test used for comparison of variance. Repeated measures analysis of variance was used for tests with serial measurements. All within-subject F-tests were based on the Huynh-Feldt corrected p-values. A detailed statistical report is available upon request.

2. Results & Discussion

Detailed tables of results are included in Appendix G.

2.1 Hormonal changes

Over the ACRT 24 of the recruits (56%), including 1 female experienced a clinically significant decline in FTCR (ie ≥ 30% decrease). This is a higher incidence than reported for a similar 8-week recruit-training program conducted in Spain, which demonstrated an incidence of 24% [9]. The decline in FTCR provided evidence for overtraining. Furthermore, FTCR was predictive of recruits experiencing minor injuries such as cuts and bruises (Spearman's rank correlation, $p < 0.01$). Figure 1 displays the pattern of change in FTCR and figure 2 shows the distribution of results for change in FTCR (final – initial results). FTCR was a sensitive measure of the training tempo during the ACRT.

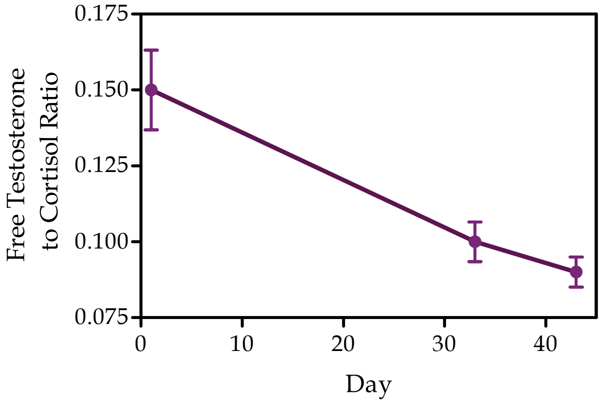

Figure 1. Pattern of change over time for the marker of overtraining: free testosterone to cortisol ratio (FTCR), mean and SEM, males only. There were too few females to analyse the female data separately. There was strong evidence of a decrease in both free testosterone and FTCR over the training period (p<0.001) free testosterone declining in both time periods (p<0.01) and FTCR declining between initial- and mid-points (p<0.001).

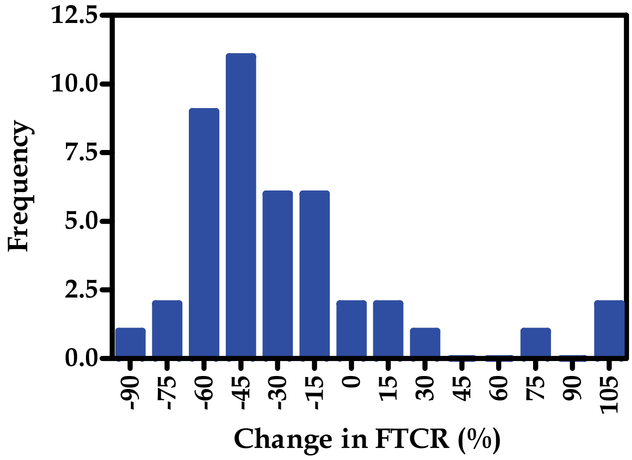

Figure 2. Change in FTCR between initial and final assessments – distribution frequency for males and females.

Recruits' serum cortisol concentration was found to be predictive of them experiencing muscle soreness (Spearman's Rank correlation, $p < 0.01$). This is common during periods of unaccustomed intense physical activity. Generally as training intensity increases plasma cortisol starts to increase, and the relative concentrations of free and bound forms of testosterone begin to change. Initially, the relative levels of free and bound testosterone appear to compensate so that the total testosterone in circulation appears unchanged (and concentration of free testosterone may increase); but after prolonged high tempo training total testosterone concentration will fall and a concomitant increase in sex hormone binding globulin capacity results in a dramatic decline in the concentration of free testosterone. Decreased concentration of free testosterone in combination with increased concentration of cortisol in the plasma causes increased protein catabolism from muscles [7].

However, appropriate physical training, which results in increased fitness can change this response, so that very fit males have plasma testosterone concentrations similar to sedentary men. So it is prolonged over-intense training of initially unfit individuals, which is most likely to affect FTCR. FTCR is considered to be a reliable indicator of training intensity [7] and there are several reports of FTCR being associated with physical performance [22, 23]. More recent studies with elite athletes suggest that a decline in FTCR up to 30% may indicate that the body has reached its best in terms of performance and that further decrements will predict the point of exhaustion [24].

Because it is the relatively unfit individuals undergoing prolonged physical training who are most likely to experience a drop in circulating serum hormone levels, these data suggest that some of these recruits did not have sufficient initial fitness to cope with the demands of the ACRT.

2.2 Positive mood changes

There was a constant decline in the level of the positive mood factor, friendliness (figure 3). While the changes in the mood factor, vigour, were not statistically significant it is noted that there was a strong correlation between friendliness and vigour scores across the training course. The decline in friendliness is important, because a high level of friendliness is needed to maintain a good team spirit. To put this in context, the mean friendliness score of recruits was less than that recorded by Defence personnel during the very stressful RAAF survival school course (table 1).

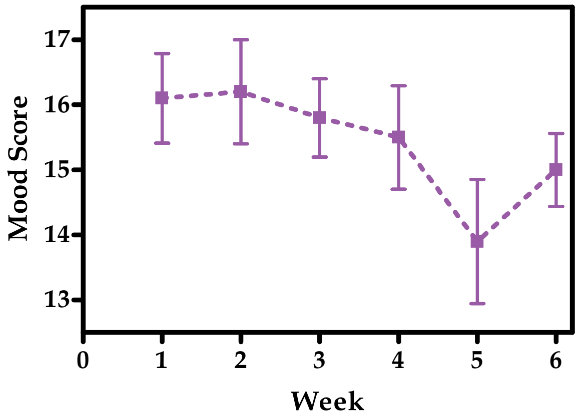

Figure 3. Pattern of change over time for mean and SEM of mood friendliness. There was strong evidence of change over the weeks of training (p=0.008). There was strong evidence of an overall decrease in friendliness over the weeks (p=0.001). Compared with the initial level, there was strong evidence that friendliness was lower in week 5 (p=0.001).

As they work together as a team recruits should be finding things out about each other and one would expect friendliness to increase over the training period, unless there was an atmosphere of unfriendly competition. One interpretation of these findings is that the ACRT is not long enough (or is too high tempo) for a group to band together as a formed unit and develop esprit de corps and high morale. This points to the need for personal time (for recreation, relaxation or rest) to be scheduled into the ACRT timetable.

2.3 Negative moods and fatigue

Mood disturbances have been shown to increase with training load in an apparently dose-dependent manner [27]. During the ACRT negative mood scores (POMS) peaked during the second week (depression, anger, fatigue, confusion and total mood disturbance) indicating an increase in stress during this week (figures 4, 5, 6, 7, 8, 9). This increase in stress coincides with the consistent finding that most serious injuries occur during the second week of ADF training courses [1]. The mean level of mood factor, confusion was higher than that experienced by personnel completing either the

RAAF survival course or a combat training exercise in Far North Queensland (table 1). Increased confusion is a common symptom reported by overtrained individuals [11].

Fatigue variables also peaked in the second week of the course and general and physical fatigue remained elevated at the end of the sixth week. Although the recruits' perceived levels of physical fatigue were not high, they appeared mentally exhausted, with relatively high levels of mental fatigue and confusion (figures 10, 11, 12, 13).

The rise in negative emotions in the second week is normal given the increasing demands (deliberate) of the course. The decrease seen in the following weeks is encouraging, because it indicates that the training tempo/stress is moderated in subsequent weeks. However, in light of the combined adverse health and psychological/behavioural findings presented in this report, a re-assessment of the rate at which the training tempo is increased is still warranted. The results show the POMS and MFSI-SF questionnaires to be sensitive to changes in the training tempo during the ACRT.

Table 1. Comparison of mean (SD & 95% CI) POMS factor scores for three military activities[a]

	Military Activity		
	ACRT	RAAF Survival School	Ex Northern Awakening
Tension-anxiety	8.6±5.6 (7.9-9.3)	8.0±5.9 (6.7-8.0)	6.3±4.6 (5.7-6.9)
Depression-dejection	6.7±9.0 (5.5-7.9)	3.9±5.8 (2.6-5.1)	5.3±7.3 (4.2-6.3)
Anger-hostility	6.0±6.6 (5.2-6.8)	3.8±4.5 (2.8-4.8)	7.3±7.1 (6.3-8.3)
Vigour-activity	15.5±5.8 (14.8-16.2)	15.8±6.0 (14.6-17.1)	13.9±7.3 (12.9-14.9)
Fatigue-inertia	6.9±5.9 (6.1-7.7)	9.2±6.7 (7.8-10.6)	10.4±6.7 (9.5-11.3)
Confusion-bewilderment	6.7±4.2 (6.2-7.2)	5.1±3.4 (4.4-5.8)	5.0±3.9 (4.5-5.5)
Friendliness	15.1±4.9 (14.5-15.7)	16.9±5.1 (15.9-18.0)	na

[a] Mean scores for the POMS mood factors were compared with scores recorded during two previous Australian military activities: a Royal Australian Air Force (RAAF) survival school course, Townsville 2001, and an Airfield Defence Guard field exercise, Far North Queensland (Exercise Northern Awakening), 1999. During the 19-day RAAF survival course students experienced hunger, thirst, boredom, loneliness and extreme heat and cold combined with demanding physical effort [25]. Exercise Northern Awakening (Ex NA) included training for the second Air Field Defence Squadron in defence of an airfield in the form of a 10-day patrol exercise and a 2-day hostage and evacuation drill [26]. Both these military activities were designed to be physically demanding and psychologically stressful with participants recording increased scores for negative moods and fatigue. There was evidence (One-way ANOVA, with post multiple comparisons test, $p > 0.05$) that the Army recruits recorded negative mood scores similar to these military activities despite having a lower score for fatigue. There was strong evidence that recruits recorded the highest scores for confusion ($p<0.01$) and a smaller score for friendliness ($t = 2.87$, $p<0.01$).

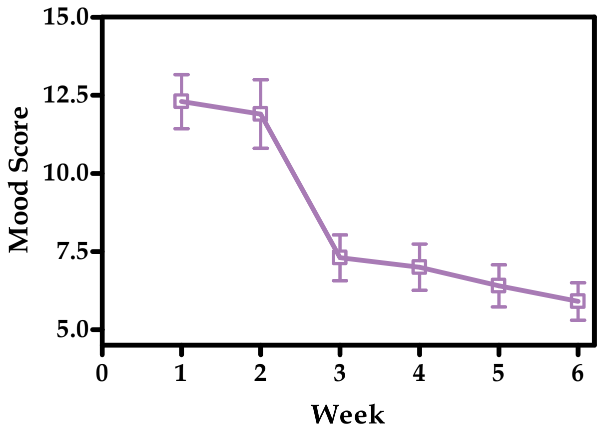

Figure 4. Pattern of change over time for mean and SEM of mood tension-anxiety. There was strong evidence of an overall decrease in tension/anxiety over the weeks (p<0.001) and also evidence that the rate of decrease diminished over time (p=0.003). Compared with the initial level, there was strong evidence that the tension/anxiety was lower in weeks 3 to 6 (p<0.001 for each comparison).

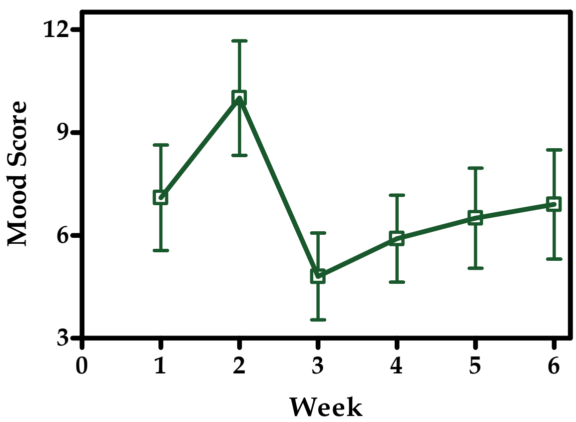

Figure 5. Pattern of change over time for mean and SEM of mood depression-dejection. There was evidence of a change over the weeks of training (p=0.026). Compared with the initial level, there was evidence of higher depression/dejection in week 2 (p=0.027), and evidence of lower depression/dejection in week 3 (p=0.038).

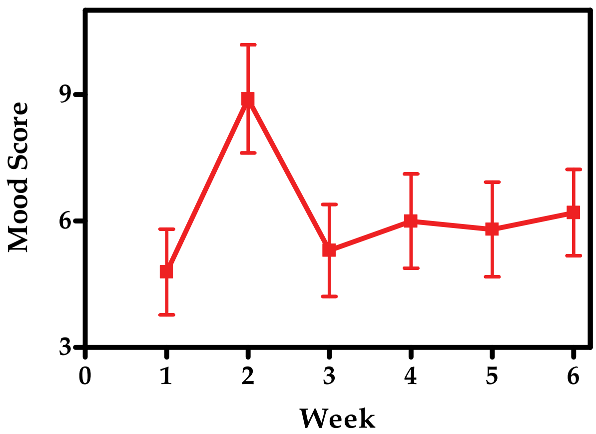

Figure 6. Pattern of change over time for mean and SEM of mood anger-hostility. There was strong evidence of change over the weeks of training (p=0.004). Compared with the initial level, there was strong evidence of higher anger/hostility at week 2 (p=0.003) and weak evidence at week 6 (p=0.062).

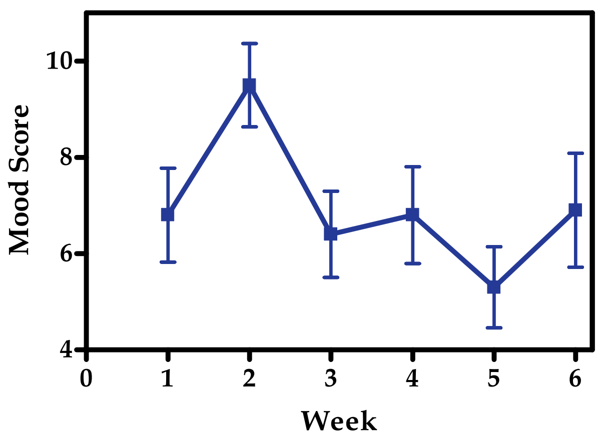

Figure 7. Pattern of change over time for mean and SEM of mood fatigue-inertia. There was strong evidence of change over the weeks of training (p<0.001). Compared with the initial level, there was strong evidence that the fatigue/inertia is higher in week 2 (p=0.002).

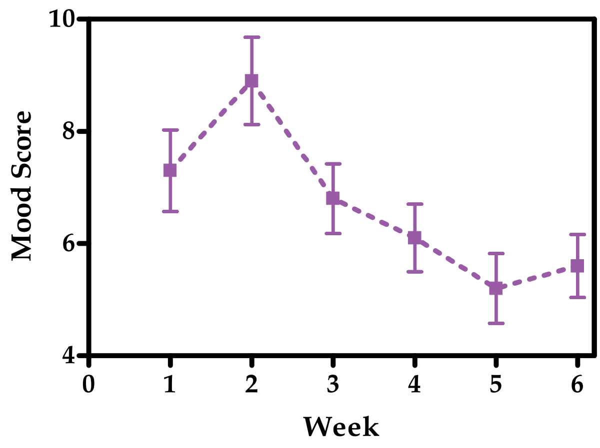

Figure 8. Pattern of change over time for mean and SEM of mood confusion-bewilderment There was strong evidence of an overall decrease in confusion/bewilderment over the weeks (p<0.001). Compared with the initial level, there was evidence that the confusion/bewilderment was higher in week 2 (p=0.028) but there was strong evidence that it is lower in weeks 4, 5 and 6 (p<0.01).

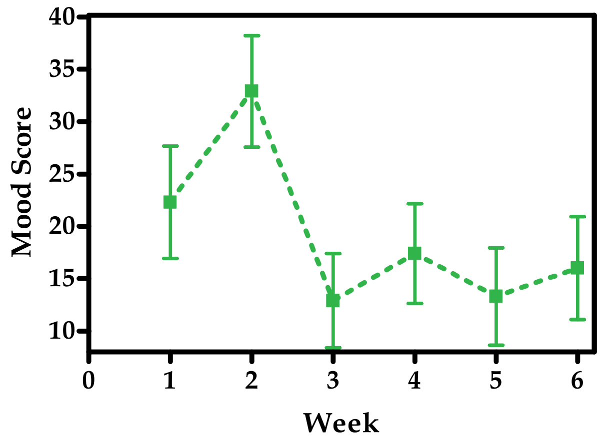

Figure 9. Pattern of change over time for mean and SEM of total mood disturbance. There was evidence of change over the weeks of training (p=0.022). There was evidence of a constant rate of decrease in total mood disturbance over the weeks (p=0.040). There was weak evidence of an increase at week 2 relative to the initial level (p=0.06).

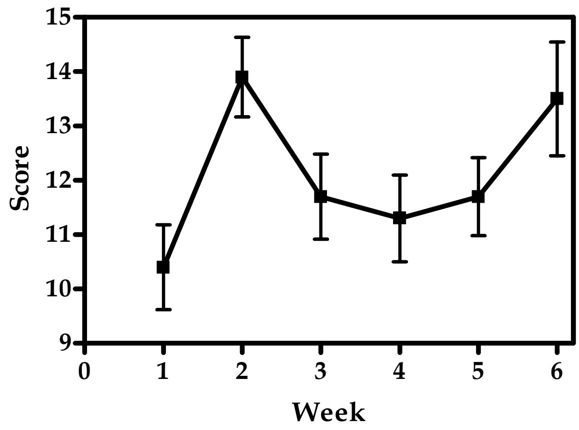

Figure 10: Pattern of change over time for mean and SEM of general fatigue. There was strong evidence of change over the weeks of training (p < 0.001). Compared with the initial level, there were significantly higher mean values in week 2 and week 6.

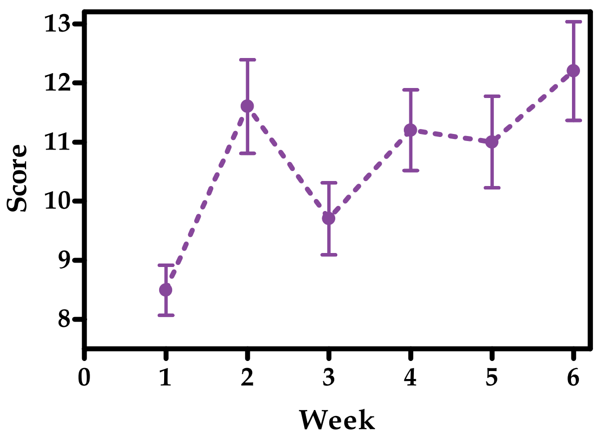

Figure 11: Pattern of change over time for mean and SEM of physical fatigue. There was strong evidence of an increase in physical fatigue over time (p=0.001). With the exception of week 3, mean levels were significantly higher than the initial level.

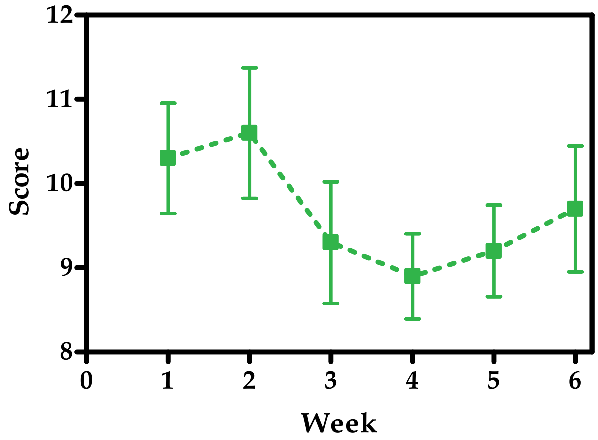

Figure 12: Pattern of change over time for mean and SEM of emotional fatigue. There was strong evidence of change over the weeks of training (p=0.002). Weeks 4 and 5 showed significantly lower emotional fatigue levels (P<0.05) and there was weak evidence of a lower level at week 3 (p=0.08).

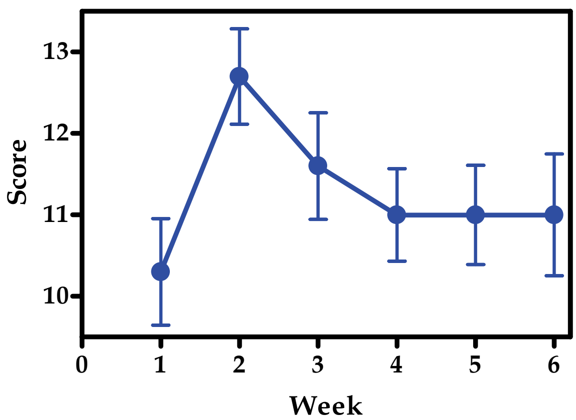

Figure 13: Pattern of change over time for mean and SEM of mental fatigue. There was evidence of change over the weeks of training (p=0.013). Compared with the initial level, there was strong evidence of higher mental fatigue at week 2 (p<0.001) and weak evidence at week 3 (p=0.07).

2.4 Cognitive hardiness

Cognitive hardiness has been used to investigate a range of human resource and psychological issues underlying why people are persistent. This study had planned comparisons of cognitive hardiness with other psychological and biochemical variables depicted in path model (figure 14). The analyses were abandoned due to the low participation rate and loss of cases.

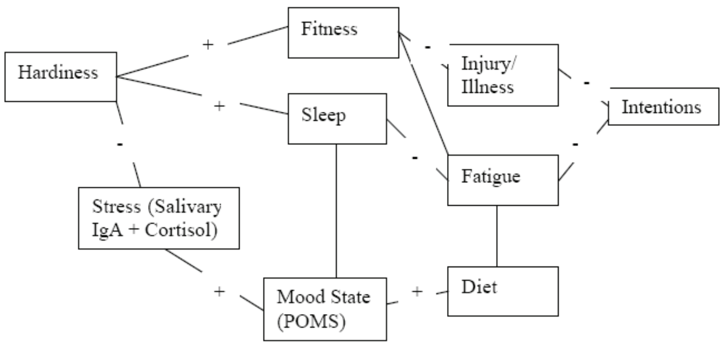

Figure 14. Planned path model to analyse Army recruit course completion.

It is expected that people selected for Army service have high cognitive hardiness and persistence. Withdrawal from the course through self-initiated discharge, medical factors such as injury and illness, and organizational incompatibility represent a significant waste of resources and time. Identifying physical and psychological factors that predict course completion can redress the wastage rates.

The participation and completion rate for the initial administration of the CHS was good (n=58) however by the midpoint only 27 useful cases remained. Unfortunately, the data for the final point was lost and the planned repeated measures statistical analysis was not possible.

Cognitive hardiness has been implicated as a factor associated with an individual's persistence to undertake challenges through to completion. In this context, the study investigated the level of cognitive hardiness associated with training completion. The finding that there was a higher mean CHS score for the recruits who completed the ACRT appears consistent with previous research. This result would reflect, at least initially, the recruit's level of intended persistence necessary to complete training.

There was evidence that initial cognitive hardness scores were positively associated with POMS factors vigour and friendliness and MSFI-SF vigour during the first week of training. Individuals with high CHS tend to be vigorous and friendly which are both essential for establishing and maintaining supportive social networks and meeting the physical challenges in the new training environment.

Unfortunately, due to the small sample size and lack of data points over the whole training period these findings cannot be generalized and consequently the assumptions described require testing in future studies.

2.5 Sleep disturbance

Sleep disturbance, as indicated by perceived poor sleep quality and many hours of wakefulness before sleep, is a common symptom of overtraining (figures 15, 16).

Sleep management affects human productivity, safety, health, and efficiency in the performance of various tasks. Typical changes in behaviour due to sleep deprivation include, deterioration in interpersonal relationships and an unwillingness to listen to all available information [28]. Mental performance is more vulnerable to sleep loss than physical performance [29]. Of relevance to this study is the effect of an accumulation of reduced sleep over the ACRT. A research group from the College of Engineering, Texas Tech University USA provides a SLEEP (Sleep Loss Effects on Everyday Performance) model as an education tool [30]. According to this model a 19 year-old student who has ~ 6.5 hours sleep per night will have difficulty coping with lectures and study material before the end of one week.

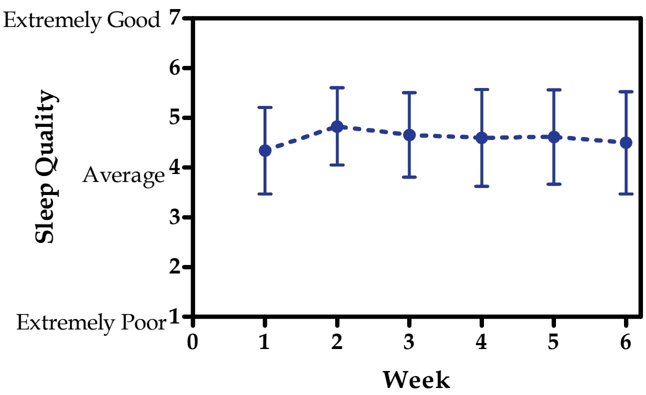

Figure 15. Pattern of change over time for mean and SD of the sleep quality score. There was evidence of a change over the weeks of training (p=0.04). Compared with the initial level, there was strong evidence of an increase in the mean sleep quality in week 2 (p=0.001). None of the other weeks showed a significant difference from week 1. It is worth noting that sleep-quality scoring in this study might be inaccurate. There appears to be substantial differences in findings between 'sleep quality' and 'hours of wakefulness', namely the significantly lower number of hours available for sleep in week 6 without a loss in sleep quality, and the increase in sleep quality at week 2 with no change in the hours available for sleep.

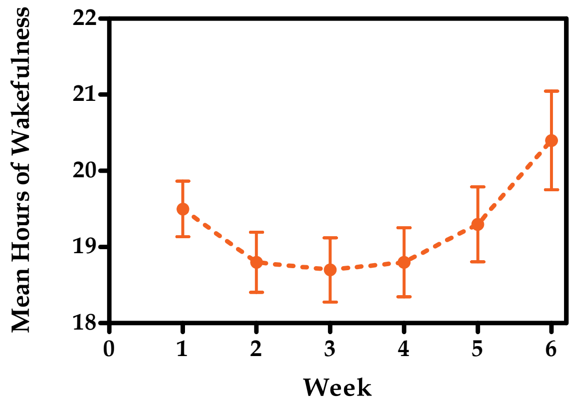

Figure 16. Pattern of change over time for mean and SEM of hours of wakefulness. There was evidence of a change over the 6 weeks of training (p=0.04). Compared with the initial level there was weak evidence that the hours of wakefulness is greater in week 6 (p=0.065).

Sleep quality and hours of wakefulness on the nights preceding the blood test were predictive of free testosterone and FTCR in males. Variability in sleep quality on day 32 explained 21% of the variability in free testosterone and 28% of the variability in FTCR at the midpoint (day 33). The relationship between FTCR and sleep quality is displayed in figure 17, with a trend line superimposed. Variability in the hours of wakefulness on day 31 explained 38% of the variability in free testosterone and 20.6% of the variability in FTCR at the midpoint (figure 18). These data suggest that accumulated sleep deprivation was a major contributor to the overtraining effect and that a simple sleep diary can be used to monitor the stress of the ACRT. Although not tested in this study, it might be useful to test for the possible association between sleep quality and injury (both minor and injury requiring medical assistance) in future work.

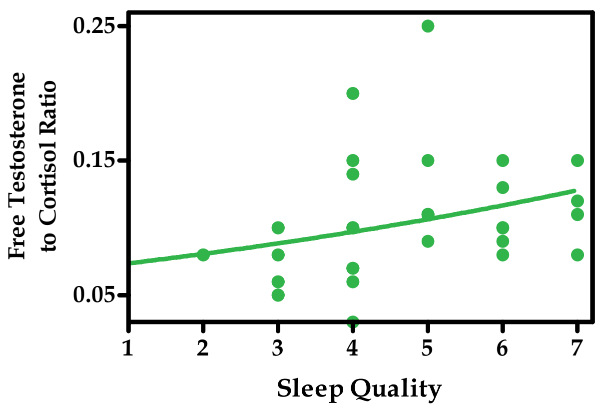

Figure 17. Relationship between the free testosterone to cortisol ratio (mean & SEM) at mid assessment and sleep quality on day 32.

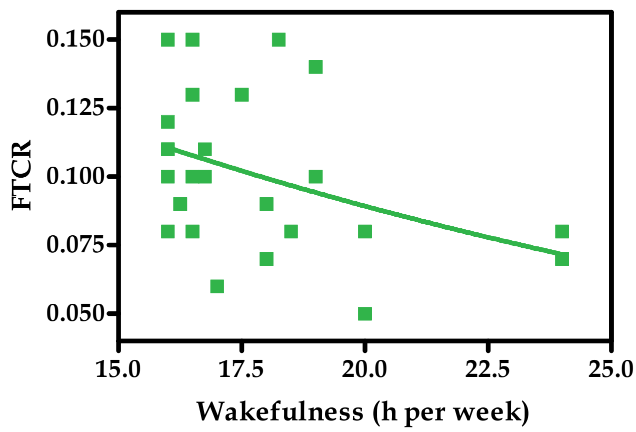

Figure 18. Relationship between the free testosterone to cortisol ratio (mean & SEM) at mid assessment and mean hours of wakefulness during the preceding week.

Although the present study did not assess cognitive function, it may well be poor sleep quality/wakefulness which explains the observed "lack of concentration" by recruits during the ACRT. Except where there is severe energy restriction, sleep deprivation appears to have the greatest negative effect on cognition. A recent investigation of the role of energy restriction and blood glucose levels as predictors of cognitive impairment during combat training found it was sleep deprivation and not blood glucose which explained cognitive impairment [31]. The effects of accumulated sleep deprivation cannot be prevented simply by providing a high-energy diet. However, the role of nutrition in increasing negative mood profile should not be discounted. For example in the RAAF study cited above, confusion was negatively associated with energy and macronutrient intake of ADGs during combat training [26].

2.6 Markers of inflammation

There was an increase in inflammation (CRP, TNFα, figure 19) during the final and most strenuous week of the course. This finding is consistent with the so-called cytokine hypothesis of overtraining [32], which argues that high tempo training without sufficient rest will produce muscle and/or joint trauma and release of injury-related cytokines. These cytokines then activate monocytes to produce large quantities of pro-inflammatory cytokines (e.g. TNFα) producing systemic inflammation, an acute phase response with production of proteins such as CRP and a hypercatabolic state—all of which has a negative impact on immune function. Extending this theory, is the proposition that by reaching the point of overtraining, individuals may become sensitized to the pro-inflammatory cytokine, IL-6, making them more likely to feel worse from subsequent bursts of the cytokine. Interleukin-6 may be a key marker for monitoring the length of time required for rest before undertaking another physically arduous task [33].

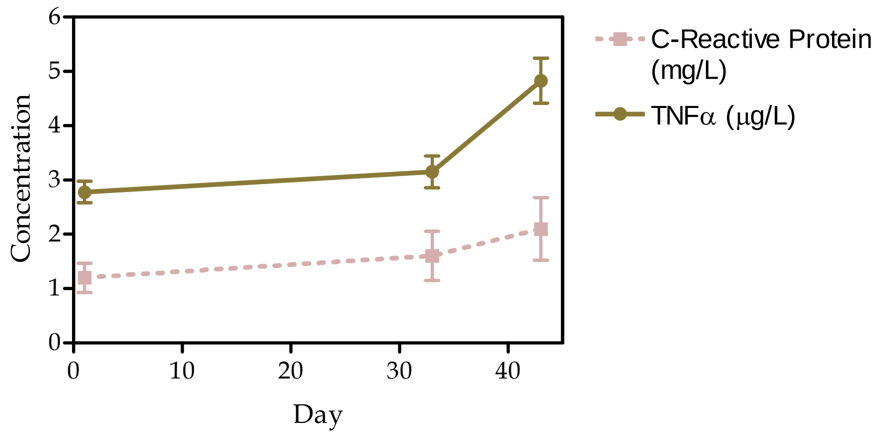

Figure 19. Pattern of change over time for markers of inflammation: C-Reactive protein (CRP) and tissue necrosis factor α (TNFα), mean and SEM. There was strong evidence of an increase in the level of CRP (p=0.001) and TNFα (p = 0.001) over the training period. In each case the evidence was focused in the midpoint and final times (p=0.001 for CRP and p=0.002 for TNFα). There was no evidence of a change between initial- and mid-points.

Intense physical activity and stress, which elicits an inflammatory response – such as the final week of the ACRT—can be undertaken without adverse health affects provided personnel are sufficiently rested before undertaking further such activities. The provision of anti-inflammatory measures (e.g. improved diet and drug interventions) might be used to prolong the period for which the level of activity can be safely maintained.

2.7 Immune function

Recruits' immune function at the start of the ACRT was predictive of URTI and skin rashes during the course (see Section 3.11). Markers of immune function (white blood cell count, neutrophil count, lymphocyte count, and neutrophil to lymphocyte ratio) declined dramatically by the midpoint with weak evidence of further decline in the final period (figure 20). Suppression of immune function during prolonged periods of intense exercise training is a common finding, although not necessarily indicative of overtraining [11]. It is rare for individuals to become clinically immune deficient during regular physical training. The most likely risk, as was the case here, is an increased incidence of URTI. An extreme situation can exist though, where training combines adverse environmental conditions with inadequate nutrition and strenuous physical activity. For example during the 1990s it was recognised that soldiers undergoing the US Army Ranger Training Course suffered higher rates of infection, including pneumococcal pneumonia, than during other training courses as a result of a catastrophic decline in immune function [34]. As a consequence steps taken to increase the nutritional status of soldiers during Ranger training courses were successful in improving the immune status of soldiers.

While the decline in immune function seen here is not worrying, recruits should have sufficient and good quality rest before entering the next military training course.

Alternatively adequate periods of rest during the course might prevent the decline seen here.

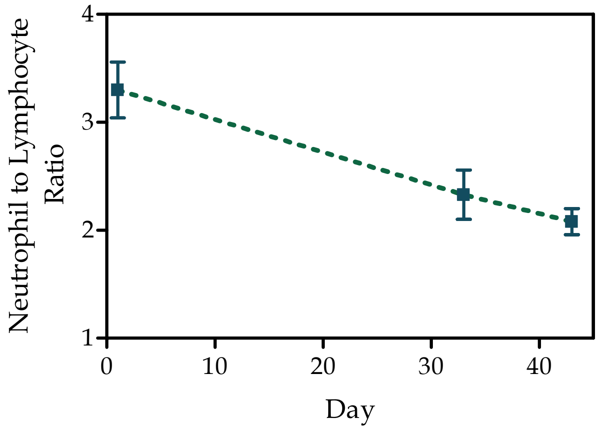

Figure 20. Pattern of change over time for immune function: neutrophil to lymphocyte ratio (mean, SEM). There was strong evidence of a decrease in the neutrophil to lymphocyte ratio (p<0.001) over the training period but with the evidence of change only occurring between the initial and mid assessments (p<0.003).

2.8 Haematology and iron status measurements

Both mean haemoglobin and serum ferritin concentrations declined across the training period, with some evidence for recruits becoming iron deficient (figure 21). Mild anaemia, decreases in serum ferritin and iron-deficiency are commonly found among overtrained athletes [11, 35]. There is a small 'iron cost' associated with increased exercise and the ability of recruits to cope is largely dependent on them having good iron stores, because it is unlikely that they will make up the shortfall through usual diet during the ACRT [36]. The evidence that this reduction in iron stores adversely affects physical performance is equivocal, except where iron deficiency anaemia is present. For most recruits, the situation was that they achieved a new steady-state with lower iron stores, but with adequate tissue levels of iron. The risk is for recruits to become iron-deficient as a result of repeated physical training programs and DSTO-Scottsdale has shown that the iron status of soldiers declines over the course of routine military field exercises [26, 37].

2.8.1 Prevalence of iron deficiency, anaemia and haemochromatosis

Iron deficiency can be classified into three stages depending upon severity: iron depletion (ID), with decreased Frt (Frt < 30 μg/L) reflecting loss of iron stores; iron–deficient erythropoiesis (IDE- decreased red cell production) indicated by a further decrease in Frt concentration (Frt < 15 μg/L) in combination with decreased transferrin saturation (not measured in this study); and finally a significant decrease in circulating Hb indicating iron-deficiency anaemia (IDA- for females < 120 g/L and males < 130 g/L) [38].

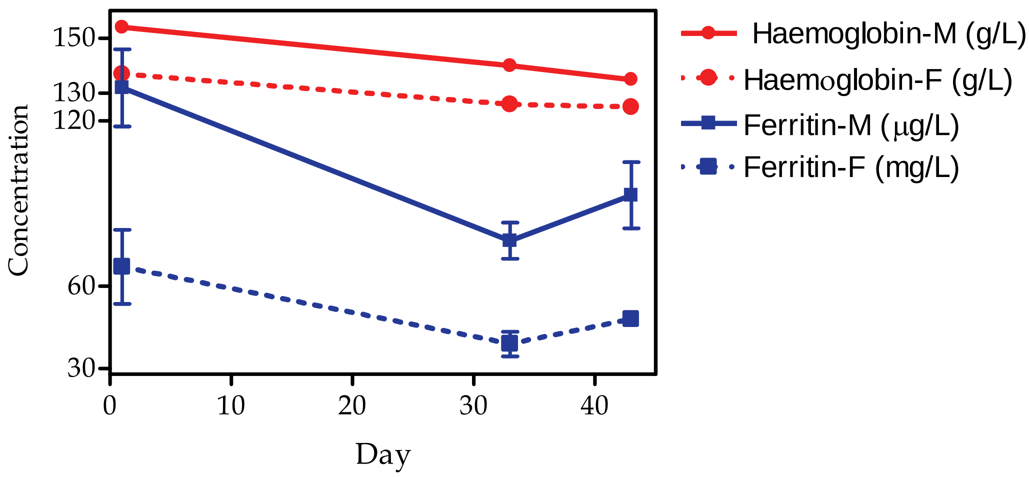

Figure 21. Pattern of change over time for iron status measures: Haemoglobin and ferritin, mean and SEM. There was strong evidence of a decrease in haemoglobin over the training period (p<0.001) with strong evidence that the decrease occurred both between initial and midpoint and between midpoint and final times (p<0.001). There was strong evidence that ferritin levels were higher in males than in females (p<0.001). However there was no evidence of a difference in the pattern of change over time between males and females (p=0.81). These findings must be treated with caution as there were only 5 females in this analysis. There was strong evidence that ferritin levels were lower at the midpoint and final times (p<0.001) but only weak evidence of a difference between midpoint and final times (p=0.09). Seven participants with elevated CRP (> 5 mg/L) were excluded from the analysis.

At the first assessment one female recruit was iron deficient (Frt = 20, Hb = 130 g/L) and dropped out of the study before the midpoint. At the midpoint two females and one male were iron deficient (low Frt, normal Hb) and three males had low/borderline Hb without low Frt. One of the females and one of the male recruits with iron-deficiency dropped out of the study before the final assessment. At the final assessment one of the males, who had low Hb at the mid assessment, had developed iron deficiency anaemia (low Hb and low Frt) and another male had a further reduction in Hb concentration. An additional 8 males had low/borderline Hb (without low Frt).

Low haemoglobin, without low serum ferritin might indicate the condition called sports anaemia, which is found among endurance athletes. This condition does not respond to iron treatment and for endurance athletes may be considered as a desirable response to exercise training [36]. However, because serum Frt was measured in the presence of inflammation (ie raised CRP and TNFα) and is itself an inflammatory protein, iron deficiency could be masked by falsely high levels of Frt. Measurement of Frt, transferrin saturation, soluble transferrin receptor and Hb would be required for a definitive study of iron status in the presence of active inflammation.

Haemochromatosis is a genetic condition with a prevalence of 1 in 300 in the Australian Caucasian community. Symptoms and signs of the early disease are similar to iron deficiency – lethargy and fatigue [38]. Elevated Frt (> 300 μg/L) can indicate

haemochromatosis. In the present study there were 3 males with Frt in excess of 300 μg/L. One of these recruits dropped out the study before the mid assessment.

This is a concerning situation because haemochromatosis is a chronic and ultimately life-threatening condition. It is, however, easily managed if diagnosed before the onset of severe liver damage. Measurement of serum Frt can be used as a screening test for haemochromatosis but further medical testing is required to make a definitive diagnosis. Despite its high prevalence, screening for haemochromatosis is not routinely conducted in Australia.

2.9 Physical performance

Overtraining has been described as "a combination of signs and symptoms of overtraining which typically causes the sufferer to feel mentally fatigued in the absence of physical fatigue and causes deterioration of performance" [39].

A generalised deterioration in recruits' performance was not observed in this study (table 3). Rather there was evidence for an increase in fitness for measures of upper body strength ($p < 0.001$,push-ups) and explosive power ($p< 0.001$, standing vertical jump). A small decline in aerobic endurance ($p < 0.001$, 2.4 km run) was recorded. This would suggest that recruits responded favourably to physical fitness training, despite experiencing symptoms of overtraining. However, the tests of performance used in this study can only be considered a 'rough guide' to the effects of fitness training, because the testing was not strictly controlled. For example the method for recording results and time-of-day were not standardised. The slight decline in aerobic endurance might be suggestive of overtraining. Furthermore the stable fitness levels recorded here were most likely less than optimal, compared with the expectations of the physical training program.

The required results for the pre-fitness assessment (ie minimum standard required for recruitment, PFA) and the minimum basic physical fitness standard (ie minimum standard for all ADF personnel, PFS) are given in table 4 [Defence Instruction (General) Pers 16-11. Department of Defence Canberra 1997.]. Based on these guidelines most recruits met the minimum physical standards easily. For example, using the PFA requirements the mean push ups were 229% and 285% of the required standard at the beginning and end of the course, respectively; for sit-ups 201% and 217% and for the initial shuttle run 121%. Although there was a decline in endurance all recruits ran times less than that required by the PFS (mean = 76%).

Table 2. Mean and range of results for fitness testing- male & female

	Push ups	Sit-ups	Standing Vertical Jump	Shuttle run	2.4km Run
	(Maximum number)	(Maximum number)	(cm)	('level')	(min:sec)
Initial test	33 ± 12	93 ± 16	67.1 ± 16.9	9.1 ± 1.3	10:11 ± 1.13
N=58	11 – 69	43 - 100	27 – 100	5.7 – 13.1	8.09 - 13.17
Final test	40 ± 11	97 ± 10	7.21 ± 17.6	NA	10:32 ± 1.02
N = 40	16 – 69	47 - 100	28 – 100		8.44 – 13.28

Table 3. Minimum requirements for standard physical fitness tests

		Push-ups	Sit-ups	Shuttle run	2.4 km run
		(Maximum number)	(Maximum number)	('level')	(min)
PFA	Male	15	45	7.5	
	Female	8	45	7.5	
PFS	Male	25	25		13
	Female	10	25		15

2.10 Weight loss

There was strong evidence for a decline in mean body weight for male recruits (mean = -2.5 kg, $t = -3.3876$, $p < 0.001$) and a non-significant weight loss among female recruits (mean = -2.0 kg, $t = -2.174$, $p = 0.095$). However, the small weight losses experienced by most of the recruits were not clinically significant. Minor degrees of hydrated weight loss (< 10% of body weight) or losses primarily of body fat have been found to have little or no effect on either physical or cognitive performance. However, it is important to rule out dehydration as the cause of weight loss, since dehydration is a cause of performance decrement [40]. Recruits who lose around 10% of their body weight should be assessed by a dietitian, because weight losses of this magnitude in initially healthy-weight individuals can cause ill health [41]. No recruits in this study dropped to an unhealthy BMI, and without data on body composition, the extent of fat or muscle loss cannot be estimated.

2.11 General health problems

The recording of health problems became unreliable after day 38. For most recruits on most days there were no health problems recorded. The only problem recorded by most recruits on at least one occasion during the ACRT was "sore muscles". Table 5 details the breakdown of health problems into the 9 categories self-recorded by the recruits.

Table 4. Mean, median and range for the number of health complaints per recruit during initial and final training periods

	Initial Period (33 days) Mean, median (range)	Final Period (5 days) Mean, median (range)
Upper Respiratory Tract Infection	4.9, 1(0 – 31)	0.2, 0 (0 – 4)
Gut/Stomach Upsets	0.5, 0 (0 - 6)	0.1, 0 (0 – 1)
Minor Trauma (cuts, bruises)	3.6, 1 (0 – 30)	0.3, 0 (0 – 4)
Injury to joints or muscles	1.7, 0 (0 – 20)	0.3, 0 (0 – 4)
Sore muscles	6.3, 1.5 (0 – 29)	0.6, 0 (0 – 4)
Skin Infection/Rashes	0.9, 0 (0 – 13)	0.1, 0 (0 – 4)
Allergic Reactions	0, 0 (0 – 2)	0.0, 0 (0 – 0)
Headaches	1.5, 0 (0 – 11)	0.1, 0 (0 – 2)
Flu	0.5, 0 (0 – 11)	0.0, 0 (0 – 0)
All categories (max score = 9 per day)	19.9, 13 (0 – 78)	1.6, 0 (0 – 12)

There was some evidence that for subjects who recorded health problems there was a relation between the expected count and the level of one or more biochemical variables. (Relationships were assessed using Spearman's rank correlation as a test statistic because the complex natures of the relationships precluded the use of parametric regression methods.) The significant relationships ($p<0.01$) were:

- URTI and neutrophil to lymphocyte ratio – negative
- Skin rash and lymphocyte count – negative
- Trauma and FTCR – negative; and
- Sore muscles and cortisol – positive.

This suggests that recruits with decreased immune function were more likely to have infective illness and overtrained recruits (low FTCR) were more likely to be injured. Increased serum cortisol is expected in individuals with sore muscles (see Section 3.2).

Injuries which required medical attention are summarized in Appendix F. For the 58 recruits participating in this study there were 216 days of medical restrictions (8.3% of work days lost) and 37 injuries over the 45-day training course. Most injuries affected the lower leg (23), including 12 foot problems and 6 knee problems. There was one stress fracture (foot). This injury incurred 90 days of medical restriction.

3. Summary and Conclusions

As described in the Introduction, the symptoms of overtraining include

- Decrease in free testosterone and FTCR;
- Decrement in positive psychology measures sa vigour, friendliness, cognitive hardiness, sleep quality;
- Increase in negative moods, fatigue, wakefulness and measures of ill-health;
- Increase in markers of inflammation;
- Decrease in ferritin;

- Decrease in immune function;
- Changes in fitness; and
- Weight loss.

Recruits undergoing the ACRT experienced symptoms of overtraining. They experienced the negative psychological symptoms often seen in overtrained individuals, namely sleep disturbance, mental fatigue, decreasing friendliness and high levels of confusion. Other symptoms of overtraining included hormonal changes, decreased iron status, a decline in immune function, weight loss and an increase in inflammation and possibly a less-than–desired improvement in physical fitness. Depressed immune function at the start of the ACRT was predictive of URTI and skin rashes during the training course and the key marker of overtraining, FTCR, was predictive of minor injuries such as cuts and bruises. Sleep disturbance was predictive of overtraining. A decline in the ability to cope may have been predictive of recruits failing to complete the ACRT. The intensity of negative psychological factors peaked in the second week. This is an expected response which reflects the deliberately challenging nature of the training course. It may therefore be a desirable effect. However, the persistently high levels of confusion and mental fatigue and the continuing decline in friendliness are consistent with overtraining and are not desirable.

Although physical performance was not measured well and cognitive performance was not measured at all in this study, it is reasonable to believe that recruits were not performing to their best ability. For example, this research was commissioned by the Commanding officer/Chief Instructor of ARTC, because of the concern that recruits were having difficulty maintaining concentration throughout the day and were taking a long time to recover after physically demanding activities. Furthermore there was some evidence for a decline in aerobic endurance by the last week of the course.

Poor iron status is of concern. Although iron status was not rigorously measured (ie transferrin saturation was not measured) there is evidence of iron-deficiency and iron-deficiency anaemia among both male and female recruits. More disturbing was the possibility that 3 recruits from the 2 platoons tested might have had the iron-overload condition, haemochromatosis.

We conclude that there was evidence for recruits being overtrained. The combined demands of ACRT, which included physical and psychological stresses, combined with inadequate nutrition resulted in a significant prevalence of overtraining symptoms such as fatigue, sleep disturbance, immune suppression, reduced iron status, high rate of minor injuries and hormonal changes. However, recruits were not pushed so hard that physical performance deteriorated greatly. Accumulated sleep deprivation might be a major contributor to the adverse hormonal changes.

These data suggest that the level of the training tempo should be adjusted to minimise the symptoms of overtraining. In particular it might be possible to adjust the training program to avoid the high levels of confusion and mental fatigue and the decline in friendliness. This might be achieved by providing recruits with periods of personal

time for recreation, relaxation or rest. Team cohesiveness might benefit from decreasing competitive behaviour (POMS anger-hostility factor) and improving interpersonal interactions (POMS friendliness factor). Better sleep management might assist in prevention of negative hormonal changes. Improved diet (as described in Part A of this report) should assist in minimising fatigue and improving sleep quality. It is important to ensure that recruits have sufficient and good quality rest before commencing their next military training course. Measures should be put in place to monitor the iron status of recruits most at risk of iron deficiency, namely females, blood donors and those experiencing an unexplained deterioration in physical performance or excessive tiredness.

4. Recommendations

1. The dietary changes recommended in part A of this report should be implemented and a watching brief for new and innovative nutritional strategies o boost performance should be maintained by DSTO or ADF nutritionists—for example the use of anti-inflammatory diet. The effectiveness of any dietary changes should be determined by monitoring the recruits' dietary intakes.
2. The pre-physical fitness standard needs to be critically assessed. There was evidence of the recruits being overtrained. In particular, over half the recruits experienced a clinically significant decrease in the key hormonal marker, FTCR. Because, it is prolonged over-intense training of initially unfit individuals which is most likely to affect FTCR, the physical fitness standard for entry to the ACRT and/or the tempo of the course should be re-examined. Furthermore recruits should be well rested before commencing the ACRT.
3. Personal time for recreation, relaxation or rest should be included in the ACRT timetable. Part A of this report noted that insufficient time was allowed for meal times – to allow recruits to eat their meal and to socialise. There was a sharp rise in the incidence of negative psychological factors during the second week of the ACRT. This might be desirable to achieve the required training effect. For example, the course is deliberately challenging in order to train recruits to be soldiers within the organisation of the Army (ie for indoctrination). However, previous studies also tell us that this is the week when serious injuries are most likely to occur. Allowing recruits time out from the high stress of the course, through planned personal time, might improve the profile of high levels of confusion and mental fatigue and low levels of friendliness seen among these recruits. The POMS and MFSI-SF questionnaires can be used to monitor any changes to the training program.
4. Strategies for better sleep management need to be considered. Recruits recorded long periods of wakefulness at night, which reduced their hours of sleep. This factor along with an inadequate supply of carbohydrate throughout the day is likely to decrease the recruits' ability to concentrate on tasks, particularly in the early morning and during the evening. One dietary recommendation made in part A, namely the recommended supper, would be helpful in improving sleep quality. Finishing classes earlier in the evenings to

allow recruits some personal time before sleep would also be helpful. The simple sleep diary used in the present study can be used to monitor changes in recruits' sleeping patterns.

5. Cognitive hardiness, or the ability to cope, was found to be a weak predictor of recruits failing to complete the ACRT. The possibility that cognitive hardiness can either be improved, or used during the recruitment process, could be the subject of further investigation. DSTO or ADF psychologists could assist in the conduct of this research.
6. Iron status should be monitored. Iron status, both iron-deficiency and iron-overload, is a problem for some recruits. These are preventable/treatable medical conditions, which can have an adverse effect on performance and health. Universal screening of recruits for iron-status would be very expensive and not warranted. However, screening of recruits at high risk, for example females and regular blood donors, should be considered. An appropriate screening test would be serum Frt. Recruits who complain of unusual tiredness/fatigue and whose aerobic endurance (ie shuttle run or 2.4 km run results) declines or fails to improve despite regular PT, should have their iron-status investigated. During intense training, recruits may have elevated Frt due to inflammation and/or decreased Hb due to the condition known as sports anaemia. Therefore an investigation of iron status during periods of arduous physical activity should include C-reactive protein, Frt, Hb and transferrin saturation. Problems of iron-deficiency and iron overload should be referred for medical attention.
7. Recruits should be given sufficient and good quality rest before embarking on further physically and/or psychologically demanding training. The decline in immune function, the hormonal ratio of free testosterone: cortisol, and iron status reflect the stresses of the ACRT. Further decline in any of these indices would be detrimental to the health of the recruits and good quality rest should allow these factors to return to normal levels.

5. References

1 Sherrard J, Lenne M, Cassell E, Stokes M, Ozanne-Smith J. Strategic Direction and Advice for Increasing Safe Participation in Physical Activity in the Australian Defence Force: A Report for the Defence Health Service; Monash University Accident Research Centre: pp 44-51, January 2002.

2 Vickers RR, Conway TL. The Marine Corps Basic training Experience: Psychological Predictors of Performance, Health and Attrition. Report 83-7, San Diego. CA, US Naval Health Research Centre:1983.

3 Pope RP, Herbert R, Kirwin JD, Graham BJ. Predicting attrition in basic military training. Mil Med 1999;164(10):710-714.

4 Skiller B, Booth C, Coad, R and Forbes-Ewan C. Assessment of nutritional status and fatigue among Army recruits during the Army Common Recruit Training, Part A: Catering services and diet. ARM 01/067, DSTO-TR-1736, 2005.

5 Bouchard C, Rankinen T. Individual differences in response to regular physical activity. Med Sci Sports Exerc 2001;336:S446-S451.

6 Fry RW, Morton AR, Crawford GPM, Keast D. Cell numbers and in vitro responses of leucocytes and lymphocytes subpopulations following maximal exercise and interval training sessions of different intensities. Eur J Appl Physiol 1992;64:218-227.

7 Aldercreutz H, Harkonen K, Kuoppasalmi K, Naveri H, Huhtaniemi I, Tikkanen H, Remes K, Dessypris A, Karvonen J. Effect of training on plasma anabolic and catabolic steroid hormones and their response during physical exercise. Int J Sports Med 1986;7 Suppl:27-28.

8 Kramer TR, Moore RJ, Shippee RL, Friedl KE, Martinez-Lopez L, Chan MM, Askew EW. Effects of Food Restriction in Military Training on T-Lymphocyte Responses. Int J Sports Med 1997;18:S84-S90.

9 Chicharro JL, Lopez-Mojares LM, Lucia A, Perez M, Avarez J, Labanda P, Calvo F, Vaquero AF. Overtraining parameters in special military units. Aviat Space Environ Med 1998;69:562-568.

10 Opstad PK. Endocrine and Metabolic Changes during Exhaustive Multifactorial Military Stress. Results from Studies during the Ranger Training Course of the Norwegian Military Academy. North Atlantic Treaty Organization RTO-MP-042 AC/323(HFM)TP/23, 2001, pp. 1-1 to 1-30.

11 Mackinnon LT. Overtraining effects on immunity and performance in athletes. Immunol Cell Biol 2000;78:502-509.

12 Derman W, Schwellnua MP, Lambert MI. The 'worn-out athlete': A clinical approach to chronic fatigue in athletes. J Sports Sci 1997;15:341-351.

13 Smith LL. Cytokine hypothesis of overtraining. A physiological adaptation to excessive stress? Med Sci Sports Exerc. 2000;32:317-331.

14 Saris WH. The concept of energy homeostasis for optimal health during training. Can J Appl Physiol 2001;26 Suppl S167-75.

15 Budgett R. Overtraining syndrome. Br J Sports Med 1990;24:231-236.

16 Reddi K., Henderson B, Meghji S, Wilson M, Poole S, Hopper C, Harris M, Hodges SJ. Interleukin 6 production by lipopolysaccharide-stimulated human fibroblasts is potentially inhibited by naphthoquinone (vitamin K) compounds. Cytokine 1995;7(3):287-290.

17 Grimble RF. Nutritional modulation of cytokine biology. Nutrition 1998;14:634-640.

18 Stein KD, Jacobsen PB, Blanchard CM, Thors C. Further validation of the multidimensional fatigue symptom inventory-short form. J Pain Symptom Management 2004;27(1):14-23.

19 McNair D, Lorr M, Droppleman L. Profile of mood states manual. Educational and Industrial Testing Service, San Diego, Calif: 1971

20 Nowack KM. Initial development and validation of a stress and health risk factor instrument. American J Health Promotion 1990;4:173-180.

21 Nieman DC. Exercise, infection and immunity: practical applications. Nutrition and Immune Function. Washington, DC National Academy Press;1999:pp363-389.

22 Hakkinen K, , Pakarinen A, Alen M, Komi P. Serum hormones during prolonged training on neuromuscular performance. Eur J Appl Physiol 1985;53:287-293.

23 Mujika I, Chatard JC, Padilla S, Guezennec CY, Geyssant A. Hormonal responses to training and its tapering off in competitive swimmers: relationships with performance. Eur J Appl Physiol 1996;74:361-366.

24 Filaire E, Bernain X, Sagnol M, Lac G. Preliminary results on mood state, salivary testosterone:cortisol ratio and team performance in a professional soccer team. Eur J Appl Physiol 2001;86(2):179-184.

25 Carins J, Booth C. Salivary Immunoglobulin-A as a marker of stress during strenuous physical training. Aviation, Space, and Environmental Medicine 2002;73(12):1203-1207.

26 Booth C, Coad R, Forbes-Ewan C, Thomson G, Niro P. Effects of medium-term ration feeding during a ground defence training exercise in far north Queensland. Mil Med 2003;168(1):63-70.

27 Morgan WP, Costill DL, Flynn MG, Raglin JS, O'Connor PJ. Mood disturbances following increased training in swimmers. Med Sci Sports Exerc 1988:20:408-414.

28 Rogers AS, Robertson KA, Stone BM. The management of irregular work/rest schedules: A reference for commanders. 2001,DERA report no. CG/WORKANDREST/v2.0/MAR2001.

29 Bradley CM, Robertson KA. Combined stressors and performance: A review.1998,DERA report no. DERA/CHA/PP5?/WP980083/1.0.

30 James M. Gregory ; Xuepeng Xie ; Susan A. Mengel. SLEEP (Sleep Loss Effects on Everyday Performance) Model. Aviat Space Environ Med 2004;75(3 suppl1): A125 — A133.

31 Owen G, Turley H, Casey A. The role of blood glucose availability and fatigue in the development of cognitive impairment during combat training. Aviat Space Environ Med 2004;75(3):240-246.

32 Lakier Smith L. Cytokine hypothesis of overtraining: a physiological adaption to excessive stress? Med Sci Sports Exerc 2000;32(2): 317-331.

33 Robson PJ. Elucidating the unexplained underperformance syndrome in endurance athletes - The interleukin-6 hypothesis. Sports Med 2003;33(10): 771-781.

34 Moore R.J., Friedl K.E., Kramer T.R., Martinez-Lopez L.E., Hoyt R.W., Tulley R.E., DeLany J.P., Askew E.W. and Vogel, J.A.,1992 *Changes in Soldier Nutritional Status & Immune Function During the Ranger Training Course,* Technical Report Natick/T13-92, US Army Research Institute of Environmental Medicine, Natick, MA.

35 Gastmann U, Petersen KG, Bocker J, Lehmann M. Monitoring intensive endurance training at moderate energetic demands using resting laboratory markers failed to recognize an early overtraining stage. J Sports Med Phys Fitness 1998;38(3):188-193.

36 Sherman AR, Kramer B. iron nutrition and exercise in Nutrition in exercise and sport, Hickson JF, Wolinsky I eds, CRC Press, Boca Raton USA 1989:pp 291 – 300.

37 Booth C, Coad R, Roberts W. Evaluation of an Australian combat ration pack as a sole nutrition source during a 23 day military exercise in the tropics. Nutr Diet 2003; 60(4):239-247.

38 Australian Iron Status Advisory Panel. www.ironpanel.org.au

39 Kent M. *Oxford Dictionary of Sport Science and Medicine*. Oxford: Oxford University Press, 1994, p 314.

40 Shukitt-Hale B, Askew W. Lieverman H. Effects of 30 days of undernutrition on reaction time, moods and symptoms. Physiol Behav 1997;62(4);783-789.

41 Committee on Military Nutrition Research. Food and Nutrition Board, Institute of Medicine (1999). *Military Strategies for Sustainment of Nutrition and Immune Function in the Field*, p 7,National Academy Press, Washington DC, USA.

6. Acknowledgements

The authors gratefully acknowledge the willing participation of the recruits, without whose cooperation the study could not have taken place. We are also very pleased to acknowledge the assistance of the Platoon staff, particularly LEUT Greg Mitchell and SGT Tyson. We would also like to extend our gratitude to CAPT Katrina Warfe, CAPT Raewyn Kirk-Lauritsen, CAPT Richard Teis, CAPT Andrew Baker, Ms Emma Stuart, CAPT Brett Woodward, Ms Anne Woodward and all of the staff at KMC for their continued support and assistance throughout this study. We also thank staff at the University of Tasmania, Charles Sturt University and the Launceston General hospital pathology who performed many of the biochemical analyses. We are grateful for Mike Bonner's (SO, Science, TCA) assistance in the interpretation of the psychology test results.

Appendix A: Recommended nutritional strategies for ARTC

1 Catering contractors delivering food services to the recruits should provide detailed menu information, including standard recipes, serving sizes and records of consumption and waste to enable a thorough nutritional assessment (by an accredited practicing dietitian) of the food provided in the Recruits Mess.

2 Problems identified with the quality and delivery of meals within the Recruits Mess during 2003 should be addressed.

3 Hot boxed meals need to be improved. In particular the serve sizes are too small and the variety of meals needs to be increased. The problem associated with providing meals to recruits who are on ROP or attending the RAP need to be addressed.

4 The menu in the Recruits Mess should allow recruits to select a diet which meets the Australian Dietary Guidelines. A sample menu and specific advice is provided in the report [4]. On average, recruits should eat a minimum of 2.5 to 4 MJ per meal and at least two carbohydrate-rich snacks, each providing 50 -100 g carbohydrate and ~1 - 2 MJ of energy. Two options are suggested for implementation of this recommendation:

a. The snacks can be derived from food already made available to the Recruits Mess (i.e. there is no extra entitlement to food beyond that currently provided by SUPMAN 4); or
b. A 'recruit supplement' could be devised that provides a minimum of 100 g carbohydrate (2 - 4 MJ of high-carbohydrate foods) to be issued as 2 between meal snacks to recruits in addition to the current entitlement under SUPMAN 4.

5 Where possible, recruits should be encouraged to select low-fat, carbohydrate-rich snack foods from external food outlets. For example, it may be possible to stock vending machines with a better selection, or allow recruits to purchase the 'healthier' food choices from Frontline rather than restricting them to confectionary and soft drinks.

6 An holistic approach to nutrition education is needed. Such a program would not only include some formal lecture material for recruits and instructors, but also involve staff and management of the various food providers.

7 To evaluate any changes made to the food delivery systems, DSTO should conduct a follow-up survey of recruits' food consumption in the 04-05 financial year.

8 A diet modelling approach should be used to assess the nutritional adequacy of the catering contract and associated aspects of SUPMAN 4. The selected diet models should take into account the possible extremes of consumption in terms of the amounts and types of food consumed and in so doing increase the probability that the actual diets of the recruits will fall into an eating pattern consistent with the Australian Dietary Guidelines.

Appendix B: Information & Consent forms

CONSENT FORM

NUTRITIONAL REQUIREMENTS OF RECRUITS DURING TRAINING AT ARTC

I,…………………………………………………. give my consent to participate in the study mentioned above on the following basis:

- I have had explained to me the aim of this research, how it will be conducted and my role in it.
- I understand the risks involved as described in the information sheet.

I understand that:

- participation in the study is entirely voluntary and there is no obligation to take part in the study;
- had I chosen not to participate there would be no detriment to my career or future health care; and
- I may withdraw at any time with no detriment to my career or to my future health care.

I am co-operating in this study on condition that:

- the information I provide will be kept confidential;
- the information will be used only for this project;
- the research results will be made available to me at my request and any published reports of this study will preserve my anonymity; and
- all research data will be securely stored on the University of Tasmania premises for a period of 5 years. The data at the University will be destroyed at the end of 5 years.

I have been given a copy of the information sheet and this form, signed by me and by one of the researchers, Ms Bianka Skiller to keep. I have also been given a copy of ADHREC's *Guidelines for Volunteers*.

Should I have any complaints or concerns about the manner in which this study is conducted I will contact the researchers in person, or contact the Australian Defence Human Research Ethics Committee at the following address: Executive Secretary, ADHREC, CP2-7-66, Department of Defence, CANBERRA ACT 2600. Telephone: 02 6266 3837; Fax: 02-6266 4982.

Participant……………………………………………. Date:……………………..

I have explained this project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Bianka Skiller……………………………………..Date:…………………….

INFORMATION SHEET

NUTRITIONAL REQUIRMENTS OF RECRUITS DURING TRAINING AT ARTC

We would like to invite your participation in a study to document any fatigue-related symptoms you may experience and assess your nutritional requirements during the Army Common Recruit Training (ACRT) course.

WHY THIS STUDY?

Demanding training loads can result in a set of symptoms often referred to as over training (or over reaching). Fatigue or tiredness, illness—particularly in the second and third weeks and lack of concentration are symptoms experienced by some recruits during the ACRT. Common overtraining symptoms include constant tiredness, moodiness, under performance, frequent colds and sore throats, changes in immune function and hormonal levels and weight loss. The symptoms are more likely to develop when physical training is combined with other stresses such as mental stress, poor sleep and inadequate nutrition. Diets which are inadequate in carbohydrate and antioxidants and which are high in saturated fats and/or n-6 polyunsaturated fats can increase your risk of developing overtraining symptoms.

This study will document the over training symptoms experienced by your platoon (e.g. fatigue, mood, heart rate, immune function, blood levels of hormones, general health, physical performance) as well as the quality of your sleep and diet. We will also estimate the energy required to complete the more demanding physical tasks such as the endurance march, Exercise Dusty Warrior and the final Challenge.

Based on the information which your platoon provides to the researchers, changes may be made to mess catering and diet in order to eliminate problems of fatigue and under performance. These changes may involve not just changes in the composition of standard catering menus, but also delivery of meals, snacks and beverages tailored to meet the demands of specific training activities. The potential significance of these outcomes is improved effectiveness of ACRT due to a reduction in the prevalence of overtraining symptoms and an improved response to training.

Ultimately we (your instructors and Defence Science & Technology researchers) want to enable you to perform physically and mentally to your best capability.

YOUR PART IN THE STUDY

Tonight you will be asked not to eat or drink anything other than water after 22:00 h. Please remember to have a glass of water before attending the Kapooka Medical Centre.

Tomorrow morning your age, gender, weight and height will be recorded. You will be asked to complete questionnaires designed to record your usual diet (at home), your fatigue level, your state of mood and how you cope with stressful situations[1]. The questionnaire session should take about 40 minutes and will be conducted before breakfast when you are attending the Kapooka Medical Centre.

While at the medical centre you will be asked to donate a blood sample (20 mL) and a saliva sample (before breakfast). These tests measure your immune function, antioxidant capacity, mild inflammation and a marker of over training. The key test for signalling the onset of over training is called the FTCR—or free testosterone to cortisol ratio. The FTCR represents a balance between anabolic (ie growing) and catabolic (ie breaking down) activity within the tissues. A decrease in FTCR of 30% or more signals the onset of over training.

Your saliva will be tested for a marker of stress called immunoglobulin-A. This is a test often used by athletes to show when their immune function is decreasing—a time when they may be at high risk of catching a head cold or sore throat. You will be asked to donate several saliva samples during the first week of the ACRT.

The pre-breakfast blood and saliva collection session will take about 1 hour for your platoon.

Every day: You will be asked to complete a simple sleep diary (immediately before bed and upon waking) and health checklist first thing every morning. This will give us information about how tired or sleepy you are at night, how well you are sleeping and any minor health problems you are experiencing. You will also be asked to record your resting heart rate— your heart rate gives us some information about your body's response to physical training. This should take less than 5 minutes.

Each week: At the end of each week you will be asked to complete 2 questionnaires which describe your level of tiredness/fatigue and state of mood during that week. This should take no more than 10 minutes. You will also be asked to provide a saliva sample (3-5 minutes).

During physical training sessions: Your physical fitness progress will be monitored under the supervision of your physical training instructor. The results of some simple tests designed to measure your aerobic fitness, endurance and muscular strength will be recorded for this study as part of your planned lessons.

Mid-course: During week 4 you will be asked to complete a food diary on three separate days. This should take no more than 15 min on each of the 3 days. [You may also be asked to donate additional saliva samples and to complete a questionnaire which asks you how you are coping with the demands of the course.[2]]

---

[1] This last questionnaire will only be completed if time permits.

[2] These additional tests (saliva and the questionnaire) will only occur if time permits.

Weeks 6 and 7: You will be asked to donate a blood and saliva sample on one morning either late week 5 or early week 6 and one morning mid week 7. These will be a repeat of the blood and saliva testing conducted at the commencement of your course ie about 1 hour require—before breakfast—for your platoon on each occasion.

At various times during these weeks you will be asked to donate additional saliva samples.

At the completion of Exercise Dusty Warrior you will be asked about the food (combat rations) you ate during the exercise – a simple food checklist. This should take no more than 10 minutes.

Additional medical information and the Defence Injury Prevention Program: During the ACRT any injuries or illnesses you have will be recorded by Defence Health for the purpose of the Injury Prevention Program. The data collected during your ACRT, which includes that described above as well as the information collected by Defence Health for the Injury Prevention Program will be exchanged so that a complete picture of any injury, illness and OTS symptoms can be viewed in order to improve the ACRT course.

WHAT ARE THE RISKS OF PARTICIPATION ?

The risks involved in having a blood sample taken are no higher than they are for a routine medical examination. An experienced phlebotomist ('blood collector') will place a tourniquet around your upper arm then draw a blood sample from the inside of your arm into a syringe. Apart from a small prick when the needle pierces the skin, little discomfort is experienced by most people. However, if the procedure makes you feel faint, you should remain sitting and place your head between your knees. By applying pressure on the puncture site after the needle is withdrawn, you may prevent any bruising.

The use of sterile technique by the phlebotomist will prevent the risk of infection.

The study also requires saliva samples. The samples will be collected using Salivettes (Sarstedt Australia); a product designed specifically for the collection of saliva samples. You will chew on a small cylinder of cotton wool (for about 2 minutes) that is then hygienically sealed and stored under refrigeration.

All consumables used to sample blood and saliva (eg. needle, gloves, swabs, tape, Salivettes) will be sterile prior to use, and the sterile technique used by the phlebotomist and laboratory researcher will prevent the risk of infection. Conventional medical practice and standards for handling human tissue will be followed in the collection and handling of blood and saliva at all times.

The physical fitness testing will be supervised by your physical training instructor and personnel with first-aid qualifications will also be in attendance. The tests will be

terminated if you indicate that you cannot continue, feel nauseous or become disorientated, or at the discretion of the PT staff, or the investigator.

HOW DO I FIND TIME TO PARTICIPATE?

Whilst involved in this study you will be considered to be 'on duty'. All of the activities will be conducted within the hours you are considered to be 'on duty'. Except for the daily sleep diary and health checklist all activities associated with this study will be scheduled into your formal timetable.

STATEMENT OF PRIVACY

Your participation in this study is voluntary. You are free to withdraw from the study at any time without detriment to your military career or health care. The information collected will be kept confidential, will be secure in a locked cabinet and nothing will be published which will identify individual participants. Your test results will not be placed on any of your Army or medical files. The information will only be used for this study as specified above. Investigators will not comment on your food selections, blood or saliva results, physical fitness results or answers to questionnaires during this time. A copy of your results and the final study report will be made available to you upon your request.

You will be given a copy of this information sheet and a copy of the statement of informed consent to keep.

Should you have any questions, concerns or complaints about this study and the way in which it is conducted, or if you would like to obtain an assessment of your dietary intake on conclusion of the study, please do not hesitate to contact the investigators:

Christine Booth, Accredited Practicing Dietitian OR Bianka Skiller
Defence Science and Technology Organisation
PO Box 147 Scottsdale Tas 7260; email: christine.booth@dsto.defence.gov.au; OR bianka.skiller@dsto.defence.gov.au

OR you may contact the Australian Defence Medical Ethics Committee :

Executive Secretary
Australian Defence Human Research Ethics Committee
CP2-7-66
Canberra ACT 2600
Ph: 02 6266 3837, Fax: 02 6266 4982; Email: ADHREC@defence.gov.au

Appendix C: MFSI-SF questionnaire

FAT-Q

Below is a list of statements that describe how people sometimes feel. Please read each item carefully, then fill in the circle next to each item which best describes **how true each statement has been for you in the past 7 days.**

	Not at all	A little	Moderately	Quite a bit	Extremely
I have trouble remembering things	O	O	O	O	O
My muscles ache	O	O	O	O	O
I feel upset	O	O	O	O	O
My legs feel weak	O	O	O	O	O
I feel cheerful	O	O	O	O	O
My head feels heavy	O	O	O	O	O
I feel lively	O	O	O	O	O
I feel nervous	O	O	O	O	O
I feel relaxed	O	O	O	O	O
I feel pooped	O	O	O	O	O
I am confused	O	O	O	O	O
I am worn out	O	O	O	O	O
I feel sad	O	O	O	O	O
I feel fatigued	O	O	O	O	O
I have trouble paying attention	O	O	O	O	O
My arms feel weak	O	O	O	O	O
I feel sluggish	O	O	O	O	O
I feel run down	O	O	O	O	O
I ache all over	O	O	O	O	O
I am unable to concentrate	O	O	O	O	O
I feel depressed	O	O	O	O	O
I feel refreshed	O	O	O	O	O
I feel tense	O	O	O	O	O
I feel energetic	O	O	O	O	O
I make more mistakes than usual	O	O	O	O	O
My body feels heavy all over	O	O	O	O	O
I am forgetful	O	O	O	O	O
I feel tired	O	O	O	O	O
I feel calm	O	O	O	O	O
I am distressed	O	O	O	O	O

Appendix D: Beliefs Questionnaire: Cognitive Hardiness Scale

Beliefs Questionnaire (CHS)

Below is a list of common beliefs people hold. How strongly do you agree or disagree with each statement? (**1 = Strongly Agree, 2 = Agree, 3 = Neither, 4 = Disagree, 5 = Strongly Disagree**).

For each item, circle the one response which best describes how strongly you agree or disagree with the statement.

	Statement	**Strongly Agree** ↓				**Strongly Disagree** ↓
1.	My involvement in non-work activities and hobbies provides me with a sense of meaning and purpose.	1	2	3	4	5
2.	By taking an active part in political and social affairs, people can strongly influence world events and politics.	1	2	3	4	5
3.	When all else appears bleak, I can always turn to my family and friends for help and support.	1	2	3	4	5
4.	I prefer to do things that are risk, exciting and adventuresome rather than adhere to the same comfortable routine and lifestyle.	1	2	3	4	5
5.	Becoming a success is mostly a matter of working hard; luck plays little or no role.	1	2	3	4	5
6.	There are relatively few areas about myself in which I feel insecure, highly self-conscious, or lacking in confidence.	1	2	3	4	5
7.	In general, I tend to be a bit critical, pessimistic, and cynical about most things in work, school, and life.	1	2	3	4	5
8.	It would take very little change in my present circumstances at work/school to cause me to leave (or try to leave) this job/school.	1	2	3	4	5
9.	I do not feel satisfied with my current involvement in the day-to-day activities and well-being of my family and friends.	1	2	3	4	5
10.	In general, I would prefer to have things well planned out in advance rather than deal with the unknown.	1	2	3	4	5
11.	Most of my life is wasted in meaningless activity.	1	2	3	4	5

12.	I often feel awkward, uncomfortable, or insecure interacting with others socially.	1	2	3	4	5
13.	I rarely find myself saying out loud or thinking that I'm not good enough or capable of accomplishing something.	1	2	3	4	5
14.	I am committed to my job/school/work activities that I am currently pursuing.	1	2	3	4	5
15.	I tend to view most work, school, or life changes, disappointments, and setbacks as threatening, harmful, or stressful rather than challenging.	1	2	3	4	5
16.	Just for variety's sake, I often explore new and different routes to places that I travel to regularly (e.g., home, school, work).	1	2	3	4	5
17.	Others will act according to their own self-interests no matter what I attempt to say or do to influence them.	1	2	3	4	5
18.	If I get a chance to see how others have dome something or get the opportunity to be taught what to do, I am confident that I can be successful at most anything.	1	2	3	4	5
19.	I expect some things to go wrong now and then, but there is little doubt in my mind that I can effectively cope with just about anything that comes my way.	1	2	3	4	5
20.	Overall, most of the things that I am involved in (e.g., work, school, community, social relationships,) are **not** very stimulating, enjoyable, and rewarding.	1	2	3	4	5
21.	I am likely to get frustrated and upset if my plans do not unfold as I hoped, or if things do not happen the way I really want them to.	1	2	3	4	5
22.	There is a direct relationship between how hard I work and the success and respect that I will have.	1	2	3	4	5
23.	I don't feel that I have accomplished much lately that is really important or meaningful with respect to my future goals and objectives in life.	1	2	3	4	5
24.	I often think that I am inadequate, incompetent, or less important than others with whom I work and that I know.	1	2	3	4	5
25.	Many times I feel that I have little or no control and influence over things that happen to me.	1	2	3	4	5

26.	If anything else changes or goes wrong in my life right now, I feel that I might not be able to effectively cope with it.	1	2	3	4	5
27.	When change occurs at work, home or school, I often find myself thinking that the worst is going tom happen.	1	2	3	4	5
28.	At the moment, things at work, homw and school, are fairly predictable and any more changes would be just too much to handle.	1	2	3	4	5
29.	You can't really trust that many people because most individuals are looking for ways to improve their welfare and happiness at your expense.	1	2	3	4	5
30.	Most of the meaning in life comes from internal, rather than external, definitions of success, achievement, and self-satisfaction.	1	2	3	4	5

Appendix E: Sleep & health diary

SLEEPINESS (before sleep) **Please rate from 1 to 7 (see table below)**	**GET UP AT**		SLEEPINESS **(after sleep)** Please rate from 1 to 7 (see table below)	**SLEEP PERIOD LENGTH**		**SLEEP QUALITY** Please rate from 1 to 7 (see table below)	**Hayfever cold, sinus infection, sore throat**	**Upset stomach, indigestion nausea, vomiting**	**Cuts, abrasion, bleeding, bruising**	**Injury to muscles or joints, sprains or strains**	**Sore or 'stiff' muscles**	**Rashes, sores, skin infections**	**Headache**	**Allergic reaction**	**Flu (high temperature joint pain, needing medication)**
	Date	Time		In Bed	Asleep		✓ HEALTH CHECKLIST If you experienced any of the above conditions please tick the appropriate boxes below for that day								

Sleepiness (before and after) rating:	**Sleep Quality**
1. Feeling active and vital. Alert and wide awake 2. Functioning at a high level but not at peak. Able to concentrate. 3. Relaxed, awake, not at full alertness, responsive. 4. A little foggy. Not at peak. Slowing down. 5. Fogginess. Beginning to lose interest in remaining awake. Slowed down. 6. Sleepiness. Prefer to lie down. Fighting sleep. Woozy. 7. Feeling dreamy. Sleep onset soon. Lost struggle to remain awake.	1. Extremely poor. 2. Very poor. 3. Poor. 4. Average. 5. Good. 6. Very good 7. Extremely good

Tables of results

Table 1. Measures of immune function

	Initial Assessment		Mid Assessment		Final Assessment	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
White Cell Count (x 10^9)	8.1 ± 1.9	4.7, 11.9	6.1±1.4	2.6, 9.2	6.3±1.4	3.5, 9.8
Neutrophil Count (x 10^9)	5.5±2.2	2.1, 12.9	3.3±0.9	1.5, 5.8	3.6±1.0	1.9, 6.1
Lymphocyte Count (x 10^9)	1.8±0.5	0.9, 3.1	1.6±0.4	1.0, 2.8	1.7±0.4	1.2, 2.8
Monocyte Count (x 10^9)	0.8±0.4	0.4, 2.3	0.6±0.1	0.3, 1.0	0.6±0.2	0.3, 1.2
Neutrophil to Lymphocyte ratio	3.3±1.7	1.2, 8.6	2.3±1.5	0.8, 9.5	2.1±0.8	0.3, 4.2

Table 2. Measures of iron status

	Initial Assessment		Mid Assessment		Final Assessment	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Haemoglobin-males (g/L)	154±9	134, 174	141±8	120, 158	135±9	116, 161
Haemoglobin-females (g/L)	137±2	134, 138	126±3	120, 128	125±4	120, 130
Ferritin-males (µg/L)	120±67	38, 368	72±31	31, 171	85±37	24, 171
Ferritin-females (µg/L)	67±30	34, 105	39±10	27, 53	48±5	43, 55

Table 3. Measures of inflammation

	Initial Assessment		Mid Assessment		Final Assessment	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
C-Reactive Protein (mg/L)	1.2±1.7	0.2, 9.4	1.6±2.9	0.2, 17.1	2.1±3.7	0.3, 23.5
Tissue Necrosis Factor α (µg/L)	2.8±1.3	0.9, 5.7	3.2±1.9	0.9, 10.6	4.8±2.7	1.6, 14.7

Table 4. Hormonal markers of overtraining

	Initial Assessment		Mid Assessment		Final Assessment	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Free Testosterone-males (pmol/L)	67.4±22.6	26.1, 118.1	43.4±14.9	9.6, 88.1	36.9±10.7	9.8, 57.1
Cortisol (nmol/L)	469±142	196, 750	438±63	293, 602	413±72	298, 578
Free Testosterone to Cortisol Ratio -males (FTCR)	0.15±0.1	0.04, 0.4	0.1±0.04	0.02, 0.21	0.09±0.03	0.02, 0.14
% Change in FTCR-males			-18±48	-89, 138	-27±44	-91, 104

Table 5. Body mass

Body Mass	Initial Assessment		Mid Assessment		Final Assessment	
(kg)	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Males	78.6±11.6	60.1, 99.2	76.7±9.6	60.0, 94.3	75.8±9.1	59.6, 91.7
Females	65.1±7.2	56.9, 74.2	64.1±6.5	56.5, 72.7	63.2±5.4	56.8, 70.4
BMI-Males	24.3		23.8		23.5	
BMI- Females	24.3		24		23.6	

Table 6. Measures of Mood and fatigue dimensions

Psychological factor	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Multidimensional Fatigue Symptom Inventory-Short Form						
Vigour	16.65±4.72	16.14±4.43	16.84±5.14	17.02±4.54	15.68±5.00	15.47±4.97
General fatigue	10.33±4.66	14.20±5.00	11.80±5.06	11.56±5.18	11.36±4.49	13.11±6.53
Physical fatigue	8.49±2.59	12.00±5.14	9.87±4.00	11.27±4.46	10.74±4.72	11.80±5.28
Emotional fatigue	10.43±4.12	11.38±5.19	9.43±4.45	8.93±3.39	9.32±3.74	9.51±4.61
Mental fatigue	10.53±4.39	13.40±4.3	11.70±4.16	10.95±3.78	10.94±4.19	10.73±4.67
Total fatigue	11.29±4.99	13.42±5.08	11.91±5.24	11.97±5.07	11.61±4.91	12.13±5.60
Profile of Mood States						
Tension/anxiety	12.3±5.4	11.9±6.4	7.3±4.5	7.0±4.5	6.4±4.2	5.9±3.7
Depression/dejection	7.1±10.0	10.0±10.0	4.8±7.6	5.9±7.7	6.5±9.0	6.9±9.8
Anger/hostility	4.8±6.3	8.9±7.5	5.3±6.7	6.0±6.8	5.8±7.0	6.2±6.4
Vigour/activity	16.7±5.8	16.6±5.9	16.8±4.7	15.6±5.2	14.3±5.9	14.9±6.5
Fatigue/inertia	6.8±6.1	9.5±5.2	6.4±5.4	6.8±6.2	5.3±5.2	6.9±7.2
Confusion/bewilderment	7.3±4.5	8.9±4.6	6.8±3.8	6.1±3.7	5.2±3.9	5.6±3.5
Friendliness	16.1±4.3	16.2±4.8	15.8±3.7	15.5±4.9	13.9±5.9	15.0±5.3
Total mood disorder	22.3±33.6	32.9±28.7	12.9±26.1	17.4±28.1	13.3±27.9	16.0±29.5

Table 7.Description and prevalence of injuries

Activity	Body part injured	Diagnosis	Days restricted	
			Per injury	Total for activity
Bayonet course	Lower back	Soft tissue injury	0	
	Hand	Soft tissue injury	3	
	Upper leg	Muscle strain	5	
	Fingers	Contusion	0	
	Lower leg	Muscle strain	0	8
Drill	Foot	Soft tissue injury	7	7
Home duties	Lower arm	Burn	10	10
Leopard crawling	Elbow joint	Cellulitis – soft tissue infection	9	9
Marching	Knee	Soft tissue injury	2	
	Knee	Patellotemoral pain	7	
	Knee	Patellotemoral pain	12	
	Thoracic spine	Soft tissue injury	3	
	Thoracic spine	Soft tissue injury	3	
	Ankle joint	Ligament/tendon sprain/tear	5	
	Lower leg	Muscle strain	4	36
Obstacle course	Head/face	Laceration	3	
	Head/face	Laceration	0	
	Abdomen	Muscle strain	2	
	Ankle joint	Ligament strain	7	12
Non-physical	Finger	Laceration	3	3
Physical training	Abdomen	Muscle strain	2	2
Ropes	Knee joint	Tendonitis	3	3
General training	Foot	Blister	2	
	Foot	Blister	0	
	Foot	Blister	0	
	Foot	Blister	0	
	Foot	Blister	2	
	Foot	Blister	8	
	Foot	Blister	0	
	Foot	Blister	0	
	Foot	Blister	3	
	Foot	Blister	3	
	Foot	Stress fracture	90	
	Thoracic	Muscle strain	5	
	spine	Ligament strain	10	
	Knee	Soft tissue injury	3	126
Running/jogging	Ankle	Soft tissue injury	0	0
			TOTAL	**216**

DISTRIBUTION LIST

Assessment of Nutritional Status and Fatigue among Army Recruits during the Army Common Recruit Training Course Part B: Psychological and Health Aspects

Bianka Skiller, Christine Booth, Ross Coad and Chris Forbes-Ewan

AUSTRALIA

DEFENCE ORGANISATION	**No. of copies**
Task Sponsors	
SIF, ADF Catering School, Victoria Barracks Melbourne	1 Printed
256-310 St Kilda Rd, Southbank Vic 3006	1
SO2 Catering Land HQ, Victoria Barracks, Sydney	1 Printed
SO1 HHPR/SO1 HD DHCD, CP-2-7-05,	1 Printed
SO2 Health Promotion, CP2-7-159	1
Department of Defence, Campbell Park Offices, Canberra ACT 2600	
Director Preventative Health, Campbell Park Offices	1 Printed
DG Strategic Health Policy and Plans CP2-7-094	
S&T Program	
Chief Defence Scientist	1
Deputy Chief Defence Scientist Policy	1
AS Science Corporate Management	1
Director General Science Policy Development	1
Counsellor Defence Science, London	Doc Data Sheet
Counsellor Defence Science, Washington	Doc Data Sheet
Scientific Adviser to MRDC, Thailand	Doc Data Sheet
Scientific Adviser Joint	1
Navy Scientific Adviser	1
Scientific Adviser – Army	1
Air Force Scientific Adviser	1
Scientific Adviser to the DMO	1
Platforms Sciences Laboratory	
Deputy Chief Defence Scientist Aerospace	Doc Data Sht & Exec Summ
Chief of Human Protection & Performance Division	Doc Data Sht & Dist List
Bianka Skiller	1 Printed
Christine Booth	1 Printed
Ross Coad	1 Printed
Chris Forbes-Ewan	1 Printed
DSTO Library and Archives	
Library Fishermans Bend	Doc Data Sheet
Library Edinburgh	1 printed
Defence Archives	1 printed

Library Scottsdale	1 Printed
Capability Development Group	
Director General Maritime Development	Doc Data Sheet
Director General Land Development	1
Director General Capability and Plans	Doc Data Sheet
Assistant Secretary Investment Analysis	Doc Data Sheet
Director Capability Plans and Programming	Doc Data Sheet
Chief Information Officer Group	
Director General Australian Defence Simulation Office	Doc Data Sheet
AS Information Strategy and Futures	Doc Data Sheet
Director General Information Services	Doc Data Sheet
Strategy Group	
Director General Military Strategy	Doc Data Sheet
Assistant Secretary Governance and Counter-Proliferation	Doc Data Sheet
Navy	
Maritime Operational Analysis Centre, Building 89/90 Garden Island Sydney NSW Deputy Director (Operations) Deputy Director (Analysis)	Doc Data Sht & Dist List
Director General Navy Capability, Performance and Plans, Navy Headquarters	Doc Data Sheet
Director General Navy Strategic Policy and Futures, Navy Headquarters	Doc Data Sheet
Air Force	
SO (Science) - Headquarters Air Combat Group, RAAF Base, Williamtown NSW 2314	Doc Data Sht & Exec Summ
Army	
ABCA National Standardisation Officer Land Warfare Development Sector, Puckapunyal	e-mailed Doc Data Sheet
SO (Science) - Land Headquarters (LHQ), Victoria Barracks NSW	Doc Data & Exec Summary
SO (Science), Deployable Joint Force Headquarters (DJFHQ) (L), Enoggera QLD	Doc Data Sheet
Joint Operations Command	
Director General Joint Operations	Doc Data Sheet
Chief of Staff Headquarters Joint Operations Command	Doc Data Sheet
Commandant ADF Warfare Centre	Doc Data Sheet
Director General Strategic Logistics	Doc Data Sheet
COS Australian Defence College	Doc Data Sheet
Intelligence and Security Group	
AS Concepts, Capability and Resources	1
DGSTA , Defence Intelligence Organisation	1 Printed

Manager, Information Centre, Defence Intelligence Organisation	1
Director Advanced Capabilities	Doc Data Sheet

Defence Materiel Organisation

Deputy CEO	Doc Data Sheet
Head Aerospace Systems Division	Doc Data Sheet
Head Maritime Systems Division	Doc Data Sheet
Program Manager Air Warfare Destroyer	Doc Data Sheet
CDR Joint Logistics Command	Doc Data Sheet
Guided Weapon & Explosive Ordnance Branch (GWEO)	Doc Data Sheet

OTHER ORGANISATIONS

National Library of Australia	1
NASA (Canberra)	1
Library of New South Wales	1

UNIVERSITIES AND COLLEGES

Australian Defence Force Academy

Library	1
Head of Aerospace and Mechanical Engineering	1
Hargrave Library, Monash University	Doc Data Sheet

OUTSIDE AUSTRALIA

INTERNATIONAL DEFENCE INFORMATION CENTRES

US Defense Technical Information Center	1
UK Dstl Knowledge Services	1
Canada Defence Research Directorate R&D Knowledge & Information Management (DRDKIM)	1
NZ Defence Information Centre	1

ABSTRACTING AND INFORMATION ORGANISATIONS

Library, Chemical Abstracts Reference Service	1
Engineering Societies Library, US	1
Materials Information, Cambridge Scientific Abstracts, US	1
Documents Librarian, The Center for Research Libraries, US	1

SPARES	5 Printed

Total number of copies: Printed: 17 PDF: 27

Page classification: UNCLASSIFIED

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA	1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)
2. TITLE Assessment of Nutritional Status and Fatigue among Army Recruits during the Army Common Recruit Training Course. Part B: Psychological and Health Aspects	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document U Title U Abstract U
4. AUTHOR(S) Bianka Skiller, Christine Booth, Ross Coad and Chris Forbes-Ewan	5. CORPORATE AUTHOR Defence Science and Technology Organisation 506 Lorimer St Fishermans Bend Victoria 3207 Australia

6a. DSTO NUMBER	6b. AR NUMBER	6c. TYPE OF REPORT	7. DOCUMENT DATE
DSTO-RR-0300	AR-013- 489	Research Report	July 2005

8. FILE NUMBER	9. TASK NUMBER	10. TASK SPONSOR	11. NO. OF PAGES	12. NO. OF REFERENCES
2004/1062017	ARM 01/067	DGDHS	54	26

13. URL on the World Wide Web	14. RELEASE AUTHORITY
http://www.dsto.defence.gov.au/corporate/reports/DSTO-RR-0300.pdf	Chief, Human Protection & Performance Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

Approved for public release

OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111

16. DELIBERATE ANNOUNCEMENT

No Limitations

17. CITATION IN OTHER DOCUMENTS Yes

18. DSTO Research Library Thesaurus

Nutritional survey; Defence Injury Prevention Program; Army Recruit Common Training Course; Psychological and Health aspects;

19. ABSTRACT

DSTO researchers conducted a nutritional survey of all food available to recruits at ARTC, and recruits from two platoons self-recorded their quality of sleep, symptoms of fatigue and ill health, mood state, level of coping ability and dietary intake. Fasting blood measures of immune status, hormones (serum free testosterone to cortisol ratio), inflammation and iron status were measured on three occasions. Mean total energy expenditure was estimated by the 'factorial method'. Components of physical fitness (aerobic endurance, strength and muscular endurance, and explosive power) were measured on three occasions. Height was measured initially and well-hydrated weight measured on three occasions. The study was conducted in two phases; the recommendations of the first phase, which specifically addressed dietary issues were presented in Part A of this report. The second phase, which investigated the proposition that recruits might display symptoms of overtraining, is addressed in this report. We conclude that there was some evidence for recruits being overtrained. The combined demands of the 45-day Army Recruit Common Training course, resulted in a significant prevalence of overtraining symptoms such as fatigue, sleep disturbance, immune suppression, reduced iron status, high rate of minor injuries and hormonal changes. However, recruits were not pushed so hard that physical performance deteriorated greatly. Accumulated sleep deprivation might be a major contributor to the adverse hormonal changes.

Page classification: UNCLASSIFIED